

Technology & Environment 1

M4X01974

EXTERNAL WALLS – LOAD BEARING
MASONRY AND TIMBER FRAME
CONSTRUCTION

Learning Outcomes

Aim

- To introduce the topic area of external wall constructions for low rise domestic buildings

Learning objectives

- To identify the performance requirements of external wall constructions
- How design technology responds to these requirements and influences the choice of wall type.

Load Bearing Masonry Wall and Timber Frame Wall Constructions

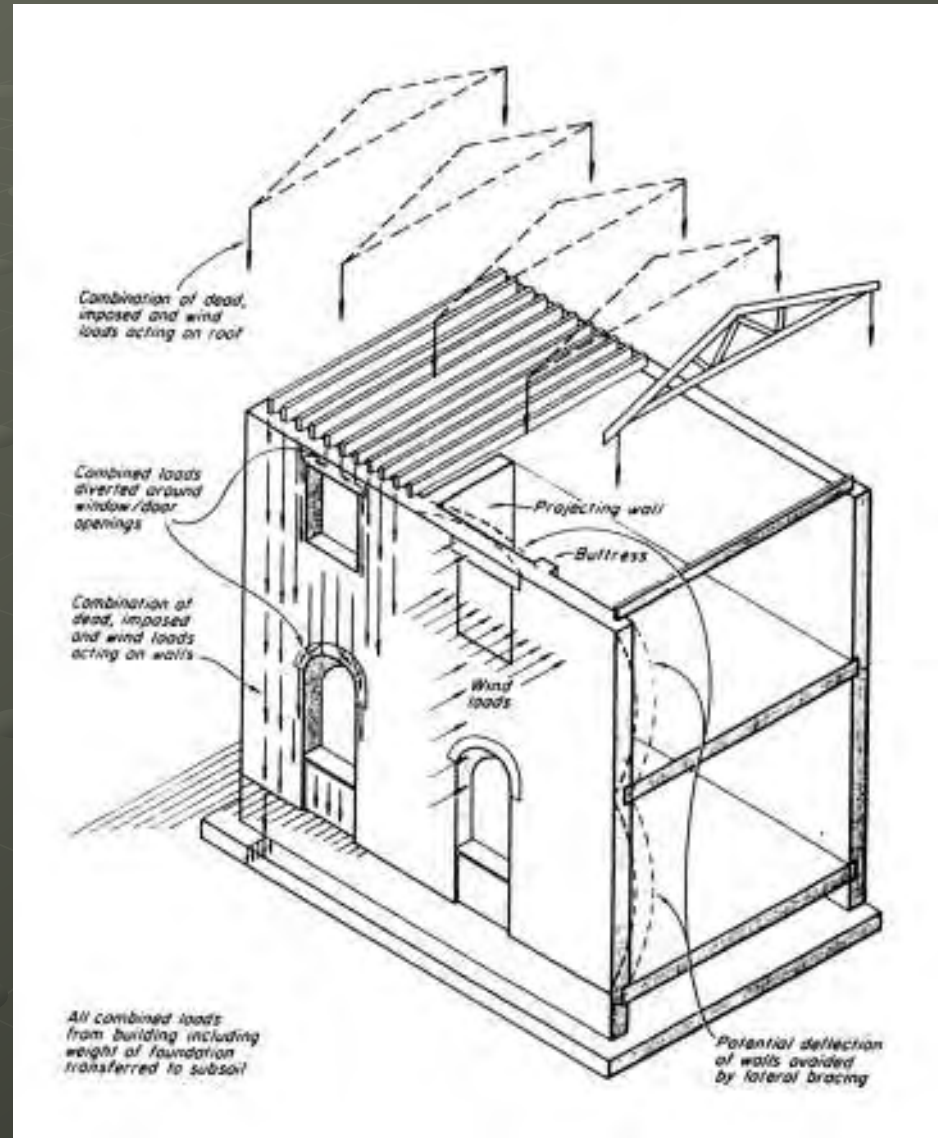
AIM: To explain methods used to construct load bearing masonry walls/timber frame walls

OUTCOMES : To understand the basic requirements for external walls

- how they are achieved
- materials used
- types of constructions

EXTERNAL WALLS

- Ext Wall Function
- The main function of external walls is to provide the environmental control between the external and internal climates (environments) of a building.

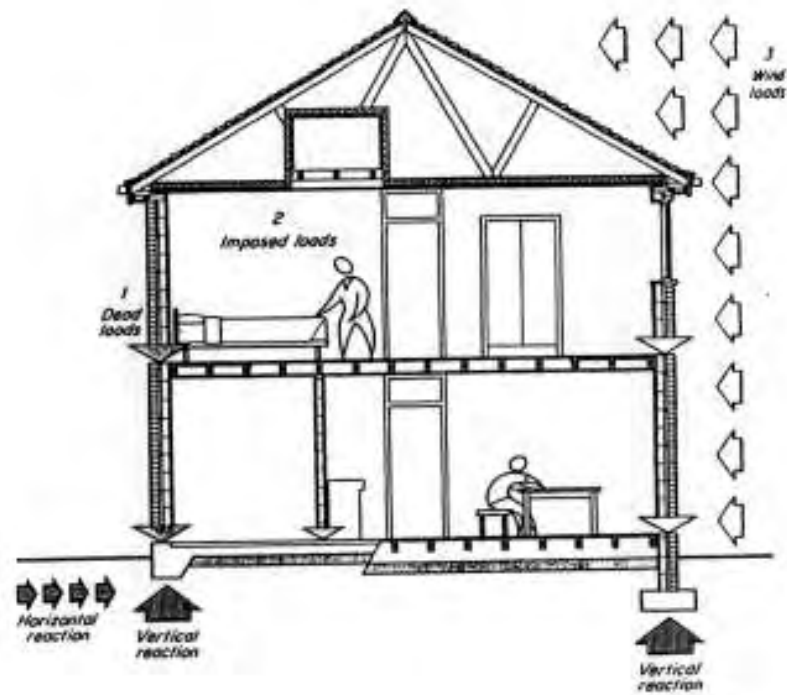
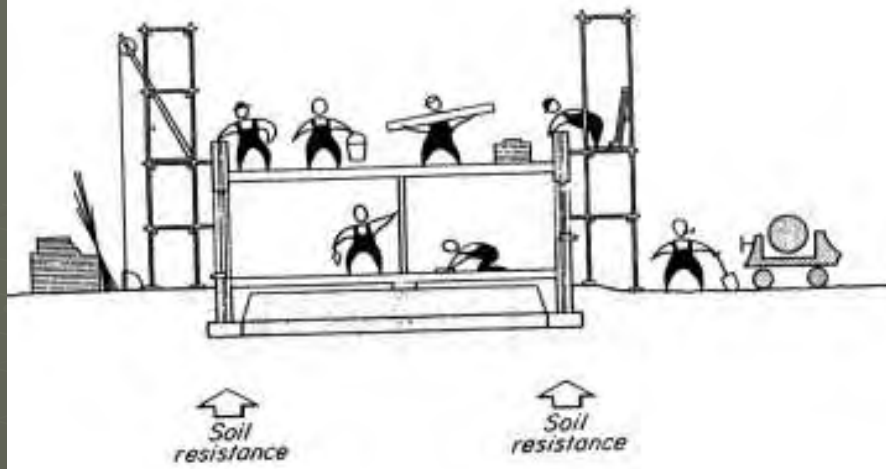


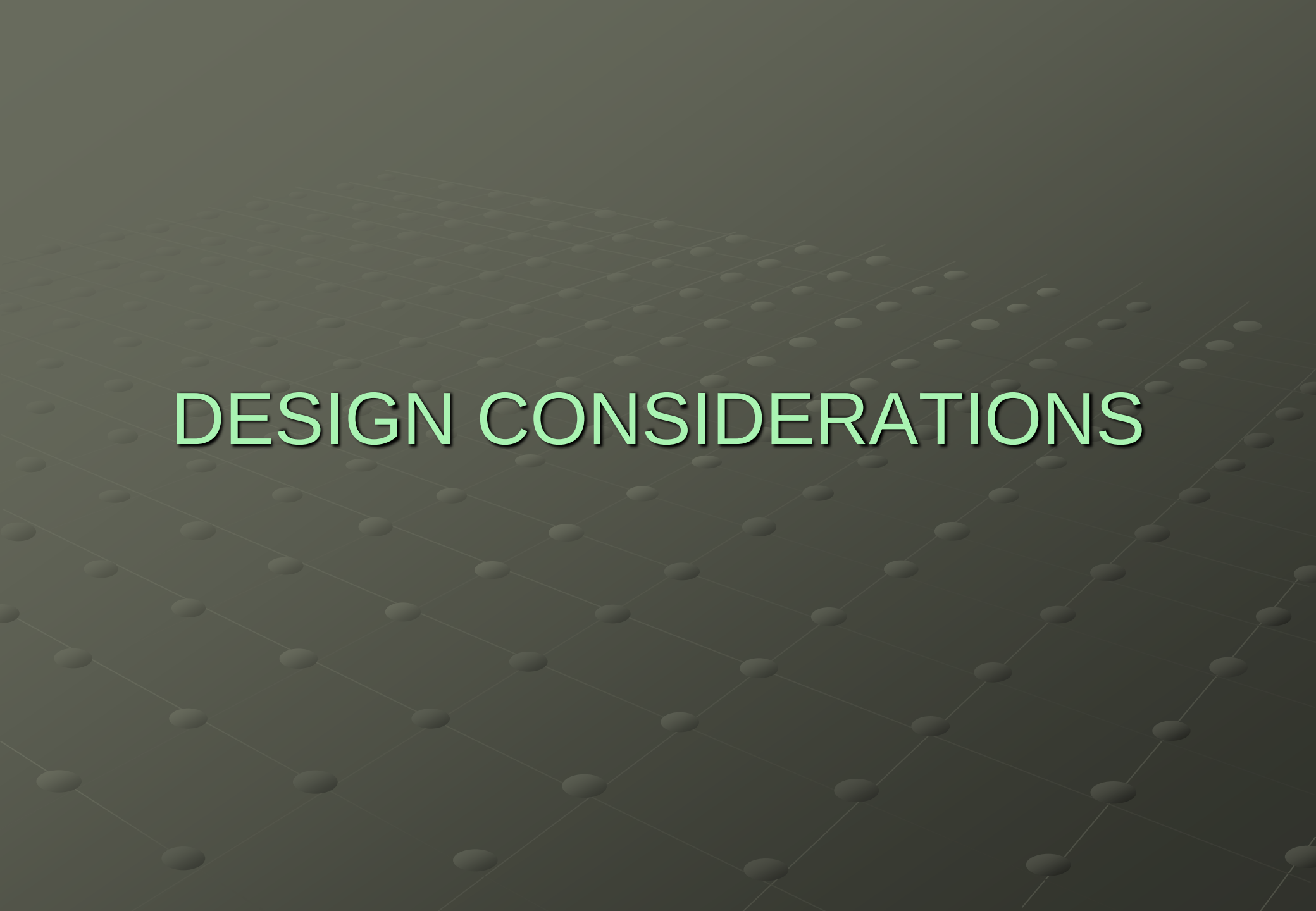
EXTERNAL WALLS

- External walls must have:
- structural stability
- resistance to moisture
- resistance to fire
- act as a sound barrier
- act as a thermal insulator
- act as a security barrier

EXTERNAL WALLS

- External walls have to support
 - dead
 - imposed
 - live
 - wind
 - loads of roof and floor construction as well as its own weight transferring loads directly to the foundations.





DESIGN CONSIDERATIONS

EXTERNAL WALLS

- Excessive loadings on external walls, and where the wall is not designed to take such ~ loadings walls will fail due to
 - crushing
 - buckling
 - overturning

EXTERNAL WALLS

- crushing - the walling material itself may fail as might the mortar in which the walling material is laid. Walls may be designed where the wall is thickened at its bottom.

EXTERNAL WALLS

- buckling - occurs where a wall is tall in relation to its thickness (i.e. when the slenderness ratio is high). Walls may need to be strengthened by
 - increasing the thickness of the wall
 - by jointing external walls to internal (load bearing) walls .
 - by incorporating external buttresses
 - including corners within the wall

EXTERNAL WALLS

- overturning - if walls are overloaded, the foundation may fail due to the soil being overstressed. Incorporation of reinforcement and /or increasing the width of the foundation itself at construction stage may negate the problem.

AESTHETICS

- External walls also play a critical part in the design, since the external walls determines the character and quality of the building.

Ty-cwrdd Bach



Chiswick House



Modern Speculative Housing





1930's semi detached house
with cavity wall construction

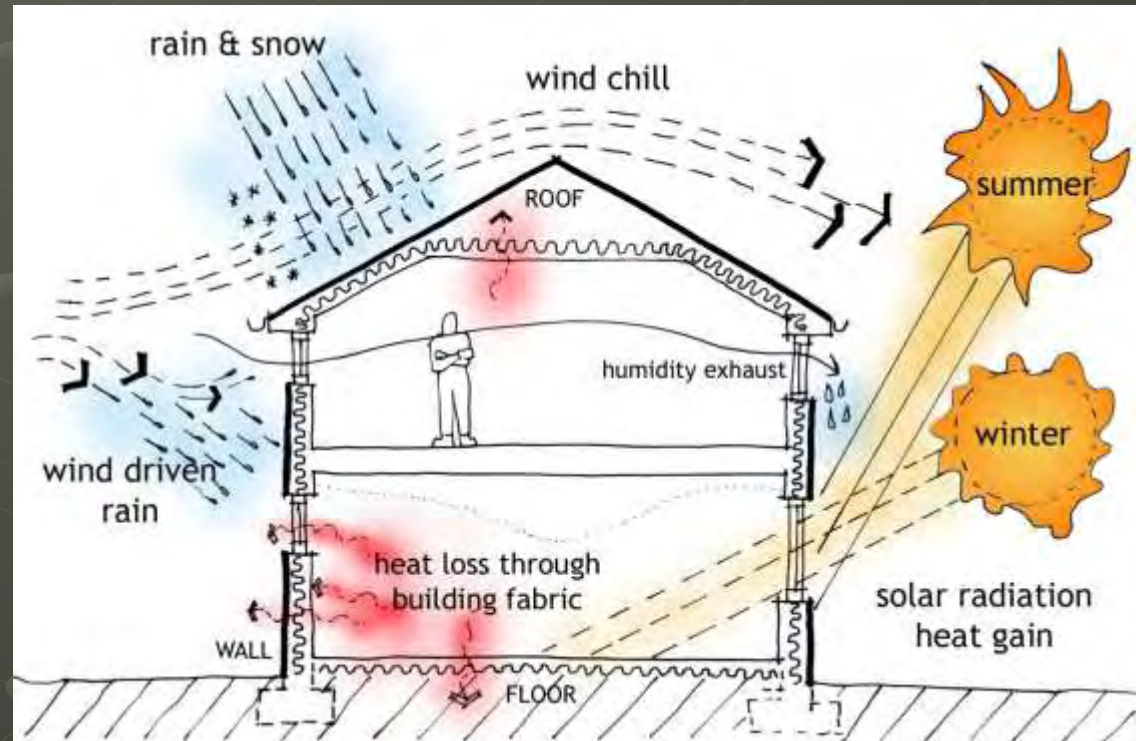


Example of a 17th century solid wall
constructed cottage with 21st
century partial filled cavity wall
constructed extension

Functional Requirements

The primary requirements for a wall construction are,

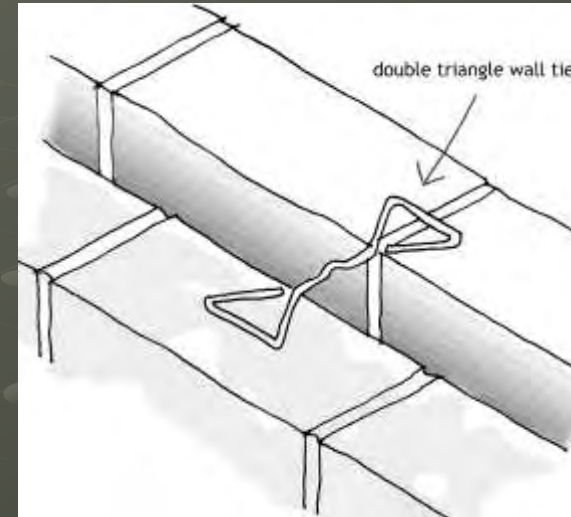
- It must be stable
- It must provide a dry internal surface
- It must reduce heat loss from the building



Materials

- Brick
- Blocks
- Stone
- Mortar
- Timber

- Wall ties
- Insulation
- External render
- Cladding



The double triangle wall tie is placed centrally and laid with the drip upwards so as to form a drip groove.

Types of Wall Construction

● Solid

- Solid (permeable)
- External insulation
- Internal insulation

● Cavity

- Cavity (traditional)
- Cavity (part filled)
- Layered or filled cavity
- Cavity Timber Frame

● Clad

Climatic Factors

MAP SHOWING CATEGORIES OF EXPOSURE TO WIND DRIVEN RAIN



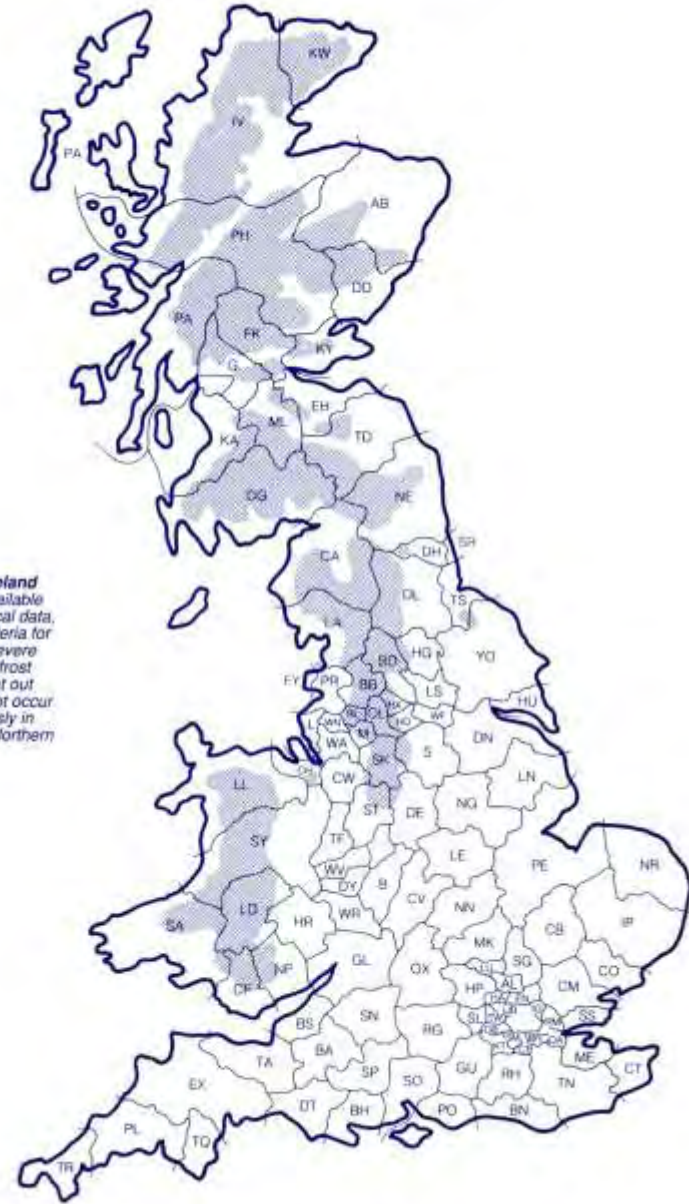
Adapted from the map in the BRE report "Thermal Insulation: avoiding risks"

Climatic Factors

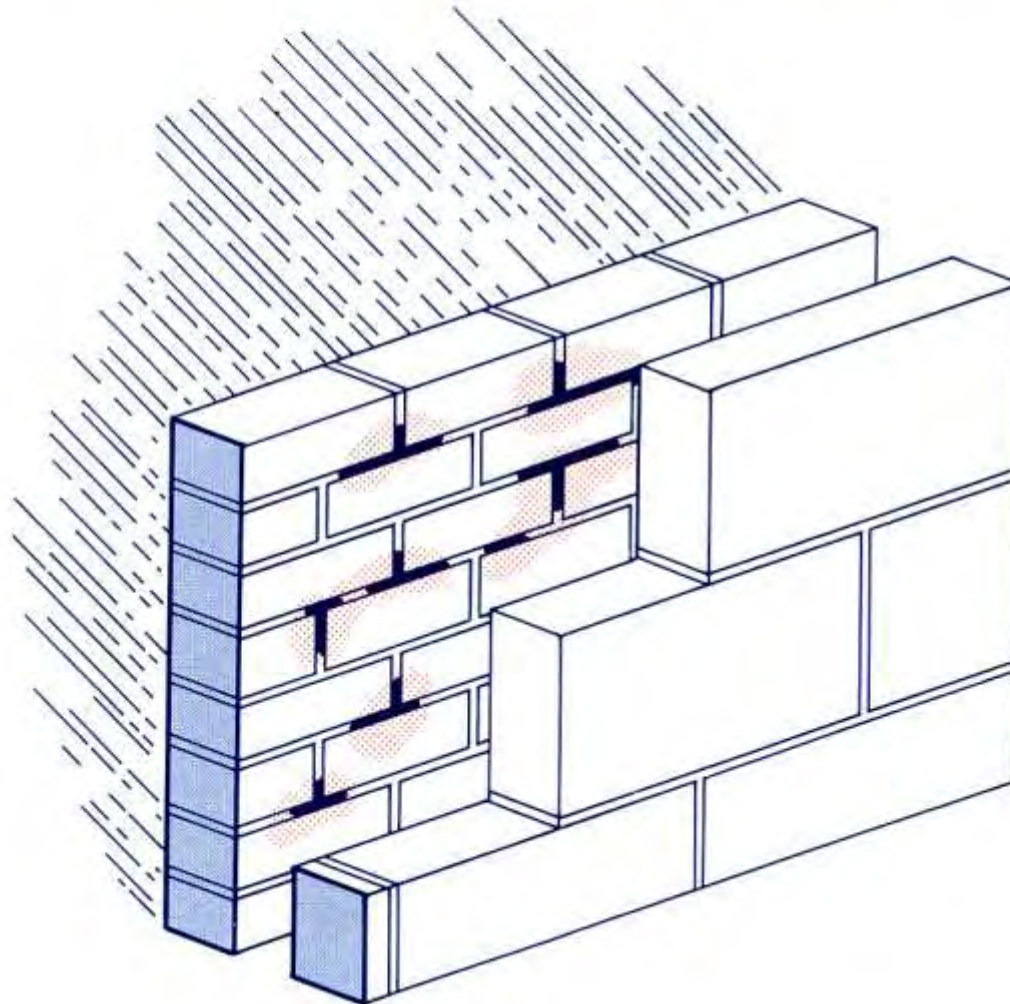
Areas of severe exposure to frost attack

The tinted areas have a frost incidence over 60 days a year, rainfall over 1000mm per year and an elevation over 90m above sea level.

Northern Ireland
From the available meteorological data, the three criteria for assessing severe exposure to frost attack, as set out above, do not occur simultaneously in any part of Northern Ireland.



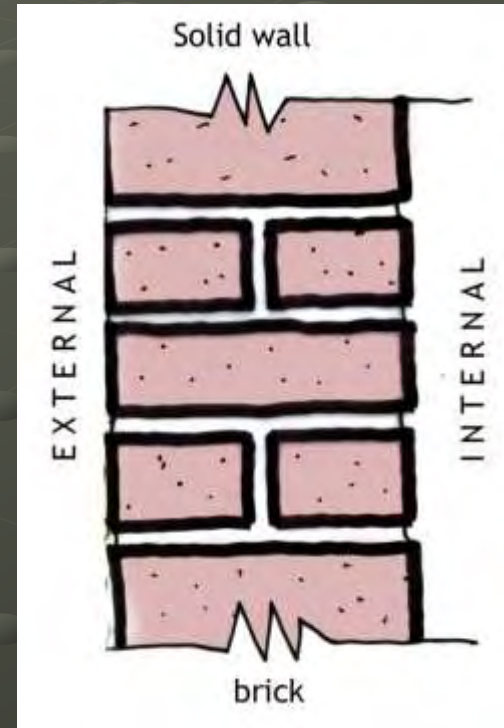
Joints should be filled to reduce the risk of rain penetration and dampness in the wall. Solid mortar bedding and fully filled perpend are particularly important in exposed areas and where the cavity is to be fully filled with insulation.



*properly filled
joints reduce risk
of rain penetration*

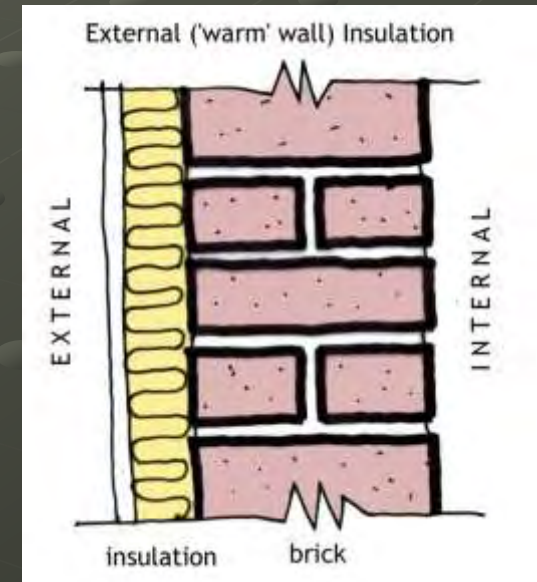
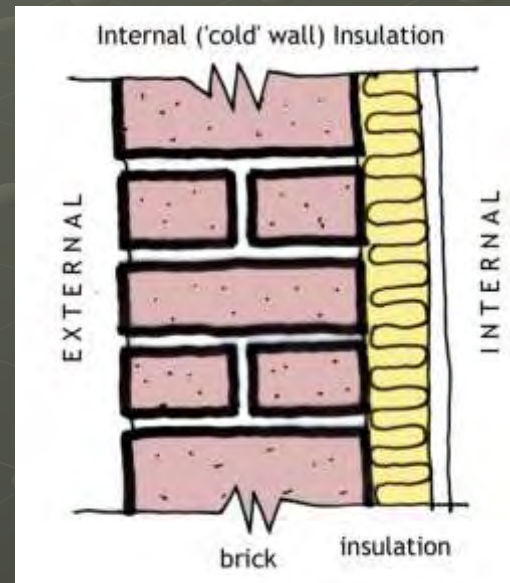
Solid (Permeable)

- Common pre 1920's
- Construction
 - Materials – brick, stone
 - Thickness of wall
- Performance
 - Absorb external moisture
 - Brick porosity & mortar joints
- Current improvements



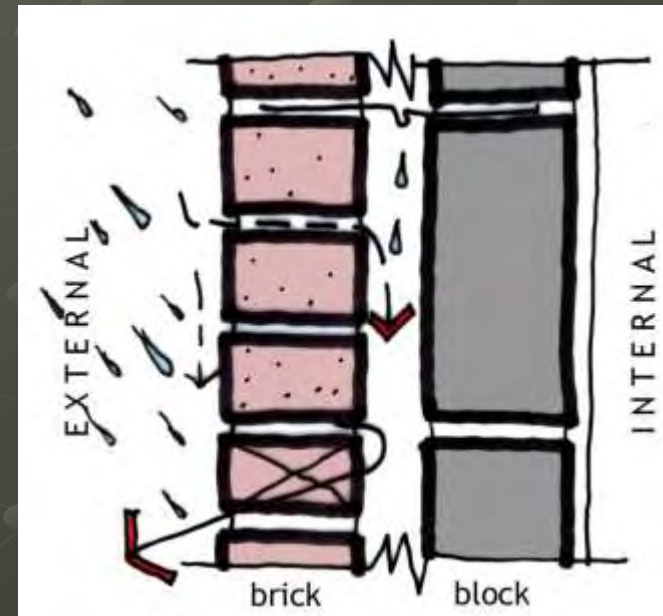
External / Internal Insulation

- Improvements of existing solid wall structures
- Modern regulations require higher thermal performance
- Improvements
 - external insulation ('warm' wall)
 - internal insulation ('cold' wall)



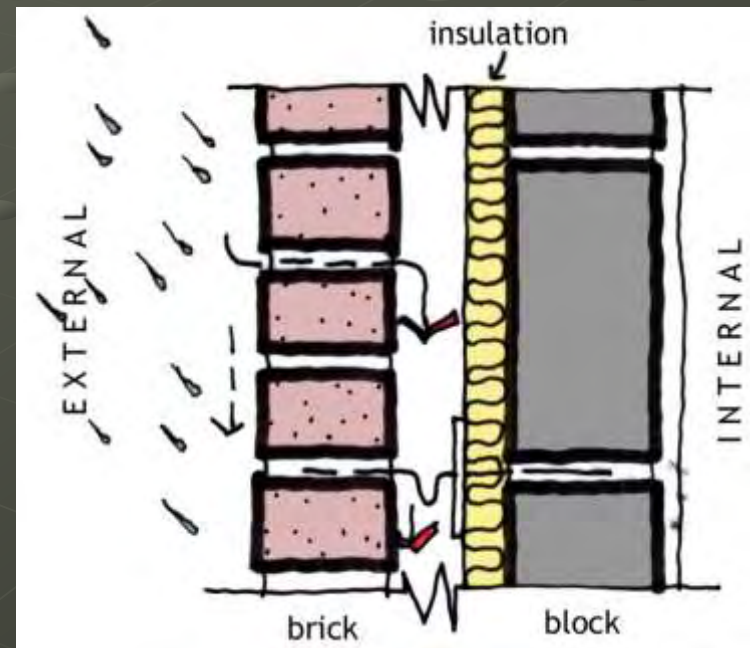
Cavity Wall Construction

- Widely used since the 1920s
- Building legislation
- Construction
 - 2 skins with cavity
 - Traditionally 50mm wide, possible 75mm
 - Linked with wall ties
- Performance
 - Inner skin remains dry
 - Damp Proof Course (DPC)

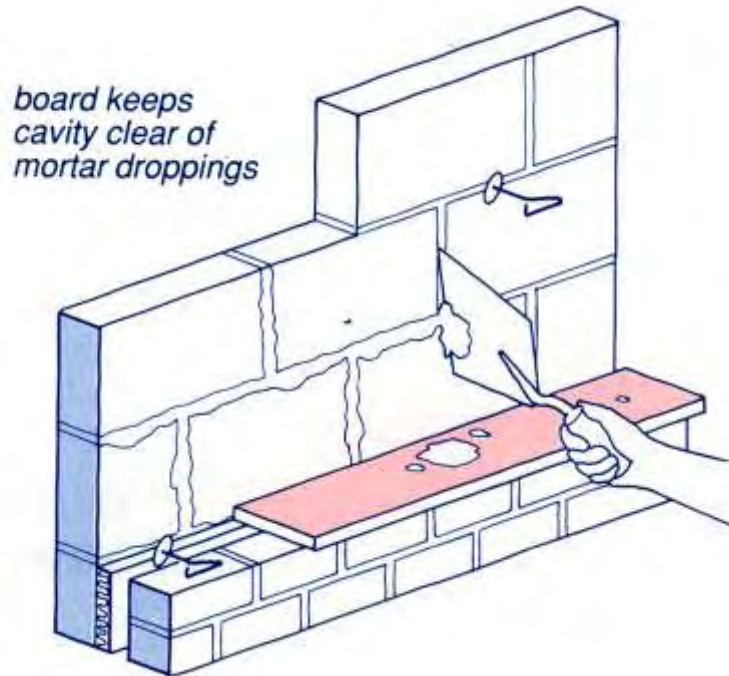


Cavity (part filled)

- Building legislation – energy conservation
- Construction
 - Insert rigid slabs of insulation
 - Held & supported by wall ties
- Performance
 - Thermal performance

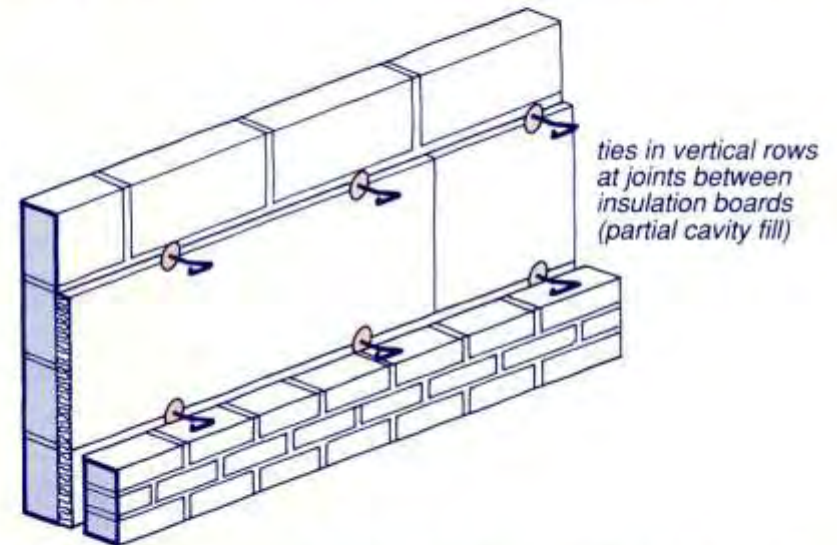


Build Sequence



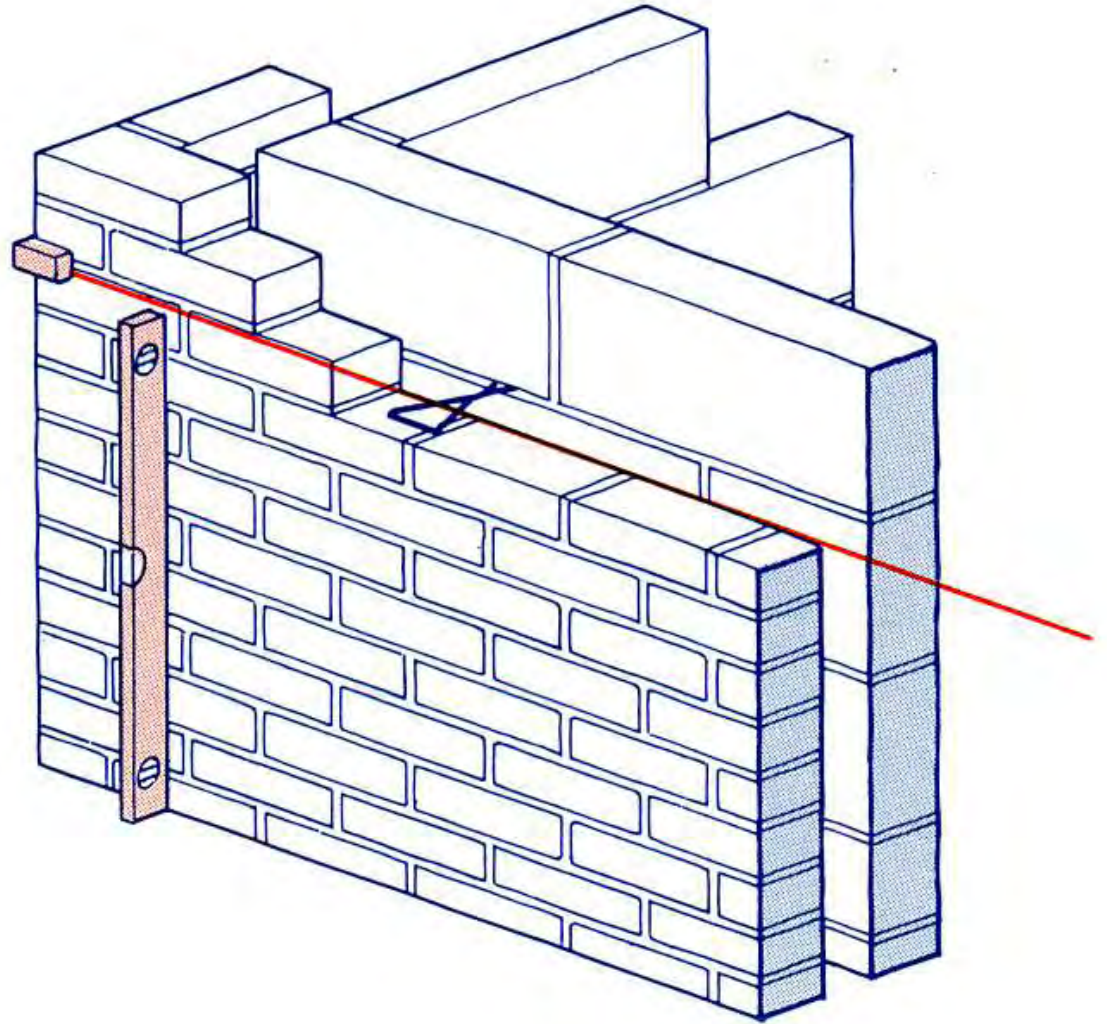
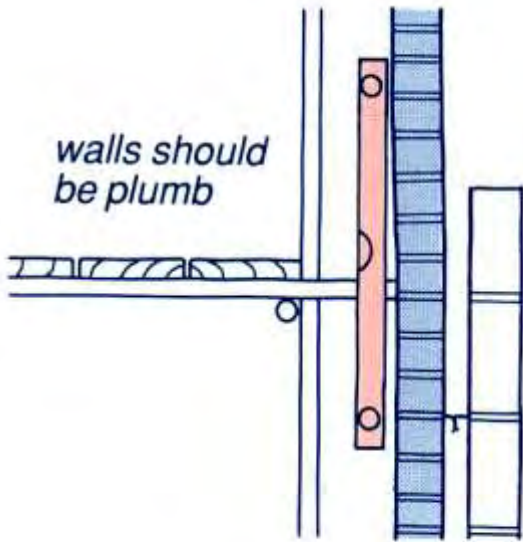
The first row of insulation boards or batts should be supported on wall ties, two ties to each board or batt.

Wall ties should coincide with horizontal joints in the insulation.



Where wall ties need to be closely spaced, for example at reveals, it is acceptable to make a clean cut neatly in the insulation to accept the extra ties. The insulation manufacturer's instructions should be followed.

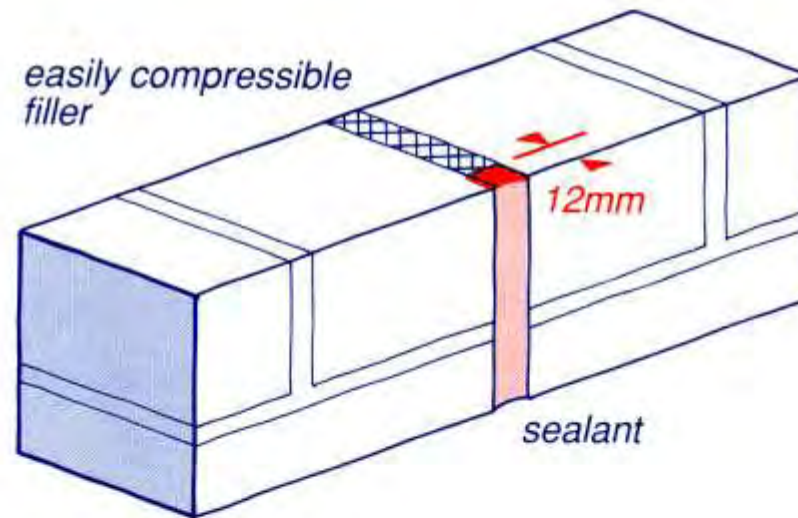
Construction Tolerances



Movement Joints

Movement joints should be formed where required by the design. Movement joints are necessary in long lengths of walling to reduce unsightly cracking. Joints are often hidden in corners, or behind rainwater pipes. Normally, movement joints are not needed in internal walls and partitions.

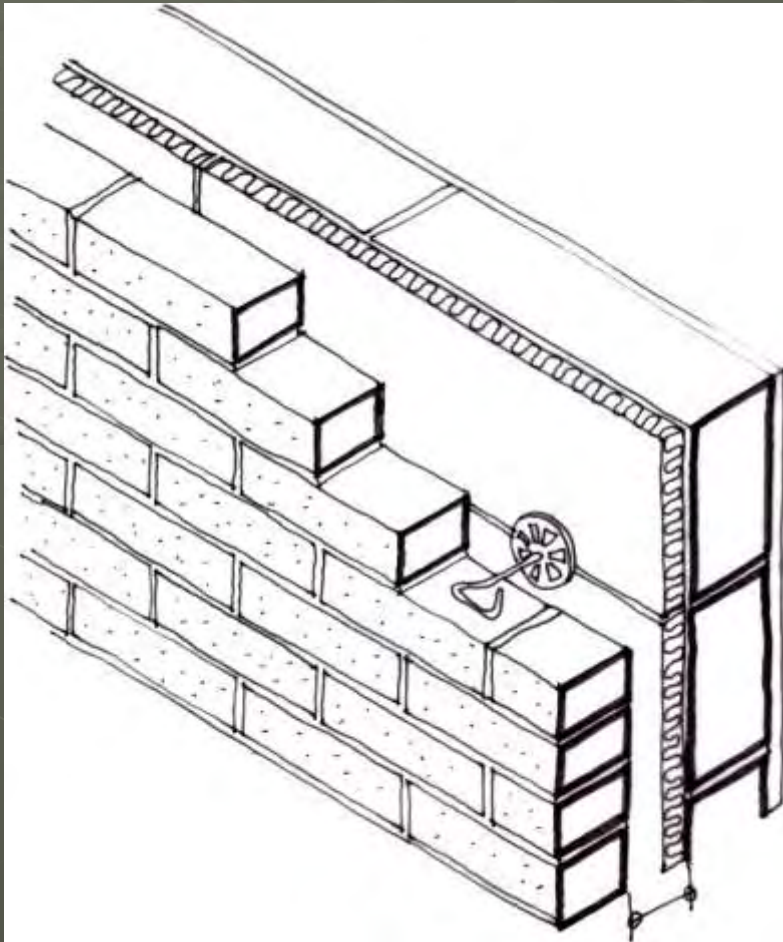
The correct materials should be used to form movement joints. Clay bricks expand and require an easily compressible material.



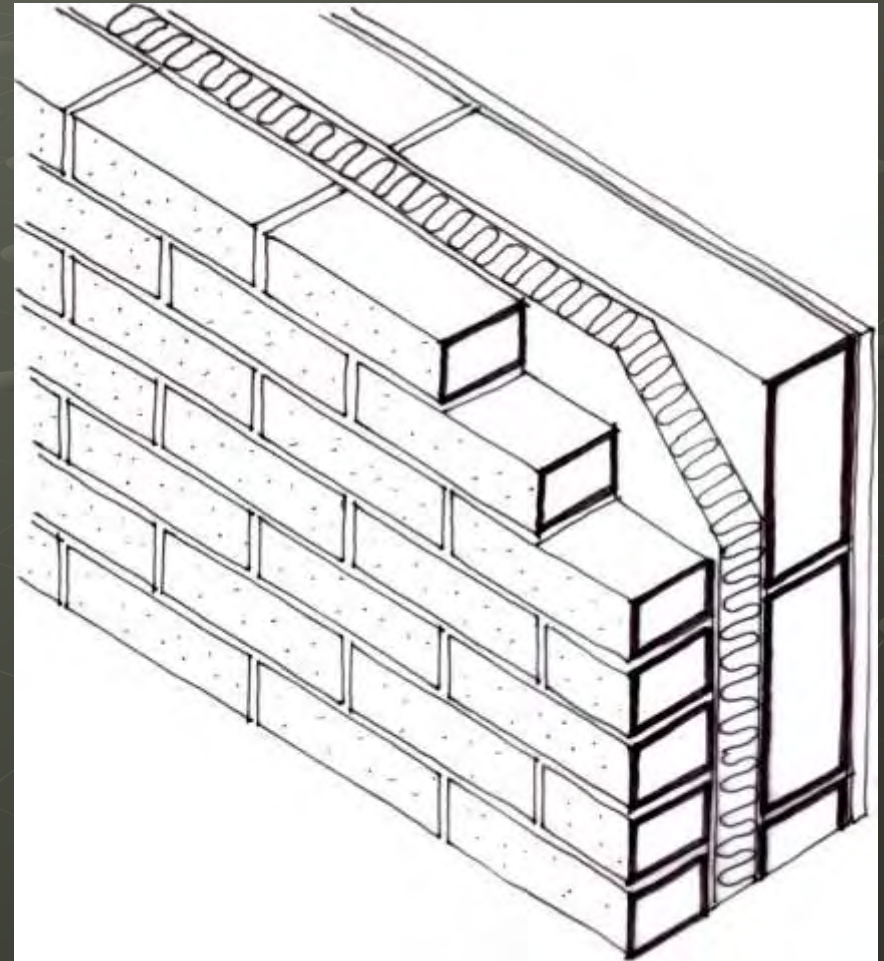
Suitable materials are:

- flexible cellular polyethylene
- cellular polyurethane
- foam rubber.

Part filled cavity wall



Filled cavity wall



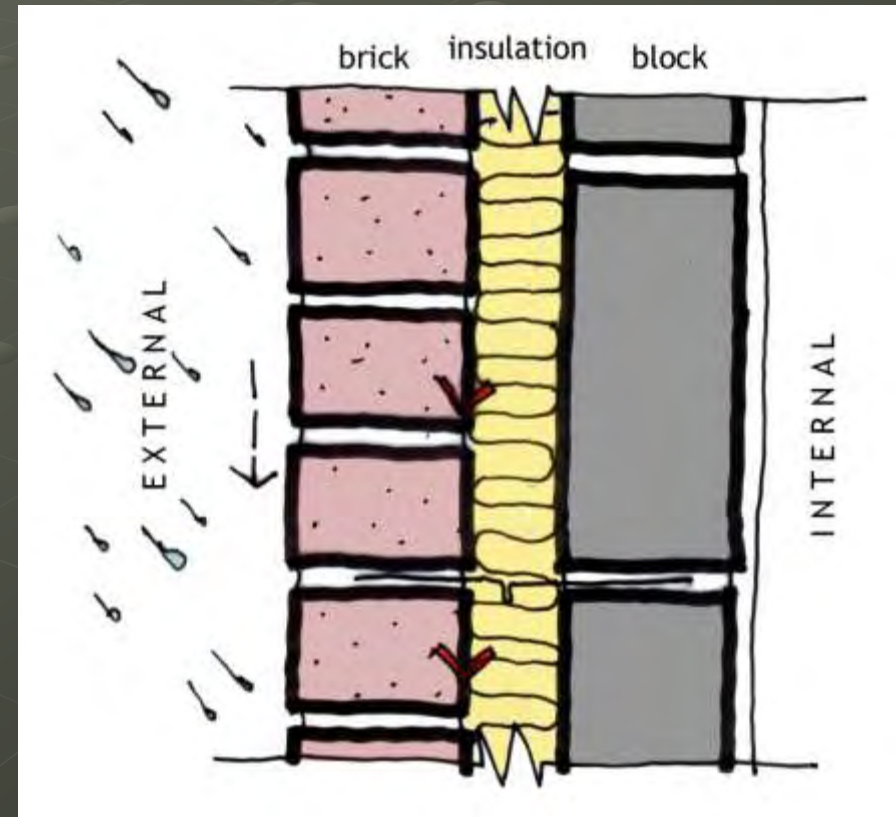
Layered or filled cavity

● Construction

- Cavity filled with insulation
- Insulation; capillary action inhibitor

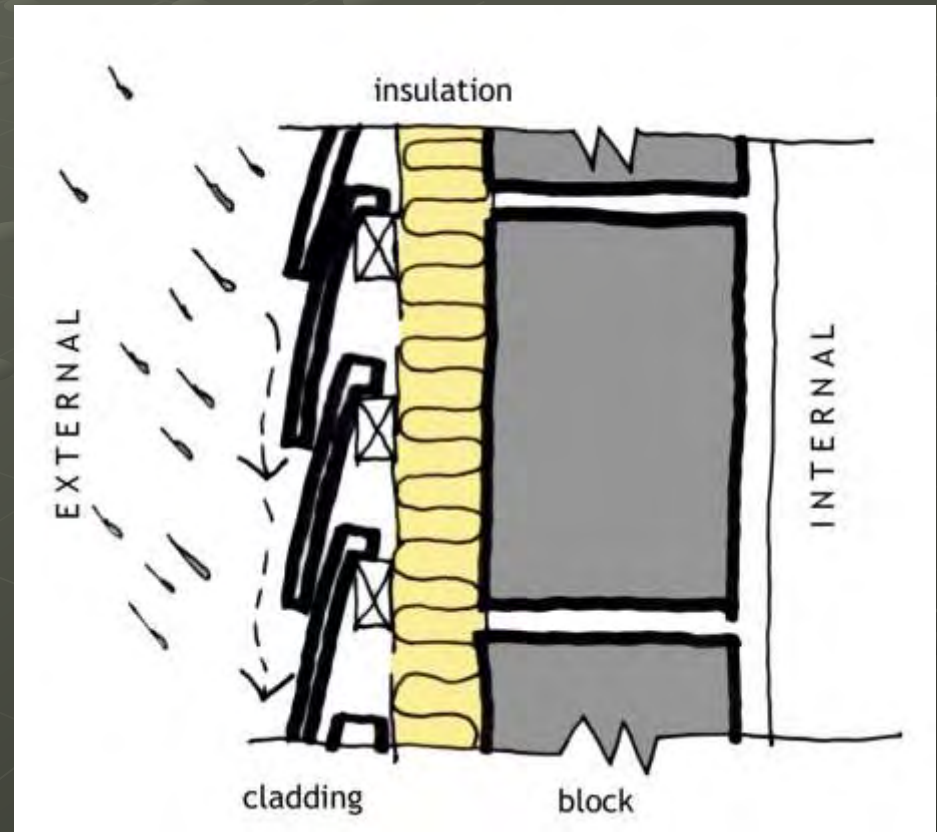
● Performance

- Increased thermal insulation



Clad

- New build and upgrading existing buildings
- Construction
 - Solid or cavity
 - Cladding with slates, tiles, boarding
 - Add insulation behind cladding
- Performance
 - Waterproofing solid walls
 - Completely waterproof



EXTERNAL WALLS

- Fire resistance:
- External walls stop the spread of fire from one building to the next by .
- use of suitable non-combustible materials
- correct use and form of construction
- suitable distribution of *unprotected areas*

Full Fill Cavity and Exposure Category

Suitable wall constructions for use with full cavity insulation

Exposure category	Suitable wall construction	Minimum insulation thickness [mm]		
		Built-in insulation	Retro-fill (other than UF foam)	UF foam
Very severe	Any wall with impervious cladding	50	50	50
	Fairfaced masonry with impervious cladding to all walls above ground storey	100	100	N/A
	Fairfaced masonry ¹	N/A	N/A	N/A
Severe or Moderate/severe	Any wall with impervious cladding or render	50	50	50
	Fairfaced masonry with impervious cladding or render ² to all walls above ground storey	50	75	N/A
	Fairfaced masonry	75	75	N/A
Sheltered/moderate	Any wall with impervious cladding or render	50	50	50
	Fairfaced masonry with impervious cladding or render to all walls above ground storey	50	50	50
	Fairfaced masonry	50	75	75
Sheltered or Very sheltered	Any wall with impervious cladding or render	50	50	50
	Fairfaced masonry with impervious cladding or render to all walls above ground storey	50	50	50
	Fairfaced masonry	50	50	50

N/A - not applicable

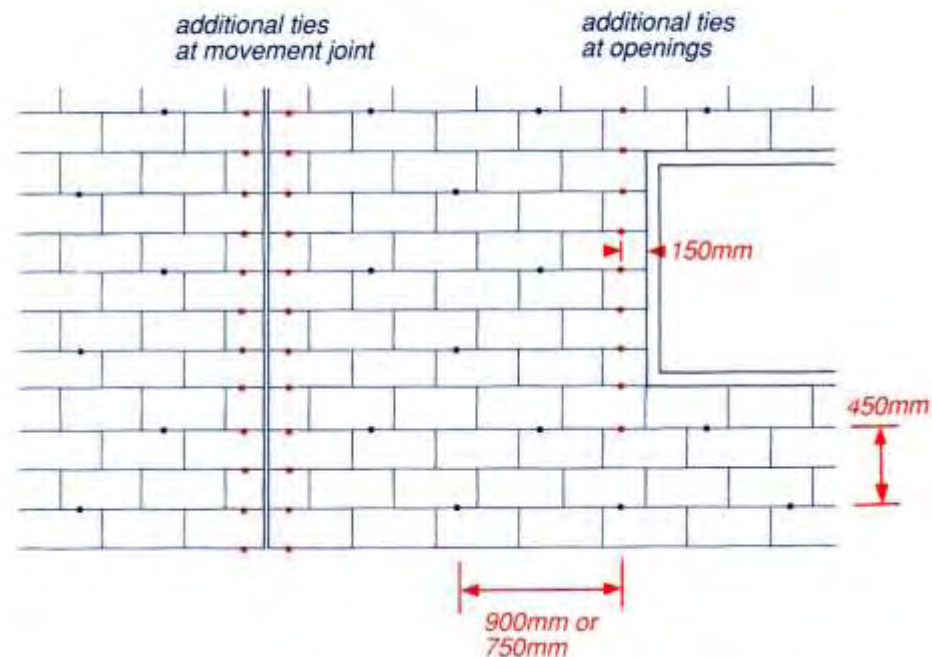
Notes

- 1 In *Very severe* exposure locations masonry should be rendered and the cavity should not contain any insulation.
- 2 The wall cavity should not be fully filled with insulation where all of the following conditions exist:
 - the exposure category is *Moderate/severe* or greater, and
 - the external leaf is constructed of clay bricks which have no upper limit on their soluble salt content (FN or MN designation bricks to BS 3921), and
 - the wall is to be rendered.
- 3 This table covers walls where the external leaf does not exceed 12m in height.
- 4 The exposure category of the dwelling is determined by its location on the map showing categories of exposure to wind driven rain.
- 5 Fairfaced masonry includes clay, calcium silicate and concrete bricks and blocks and dressed natural stone laid in an appropriate mortar (see Appendix 6.1-D) preferably with struck or weathered or bucket handle joints. Cavity walls of random rubble or random natural stone should not be fully filled.
- 6 Recessed mortar joints should not be used.
- 7 In Scotland, it is not permissible to fill the full width of the cavity with any thermal insulation at the time of construction.
- 8 In Northern Ireland and the Isle of Man it is not permissible to fill the cavity with pumped thermal insulants (for example, UF foam) at the time of construction.

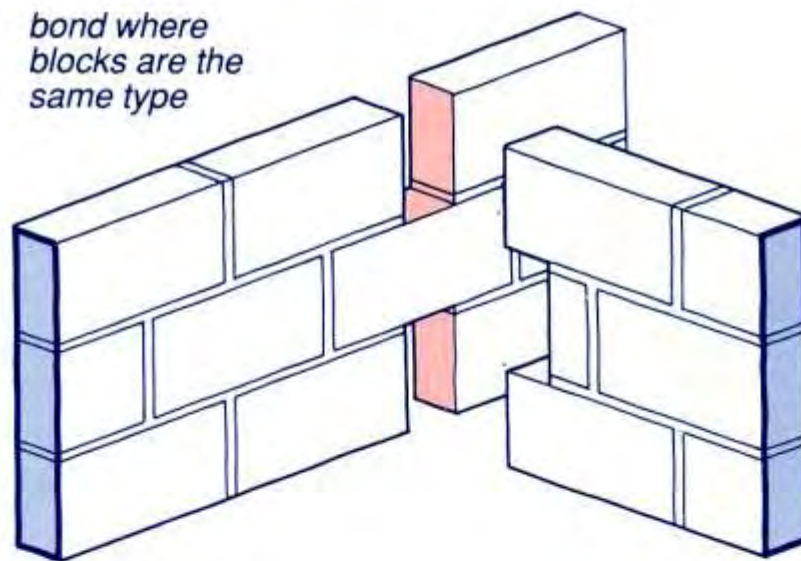
Wall ties should be spaced above and below dpc as follows:

Cavity width between masonry faces [mm]	Maximum spacing [mm]	
	Horizontally	Vertically
50 to 75	900	450
76 to 100	750	450
50 to 100 (At jamb openings, movement joints, etc)	within 150 of opening	300 or each block course

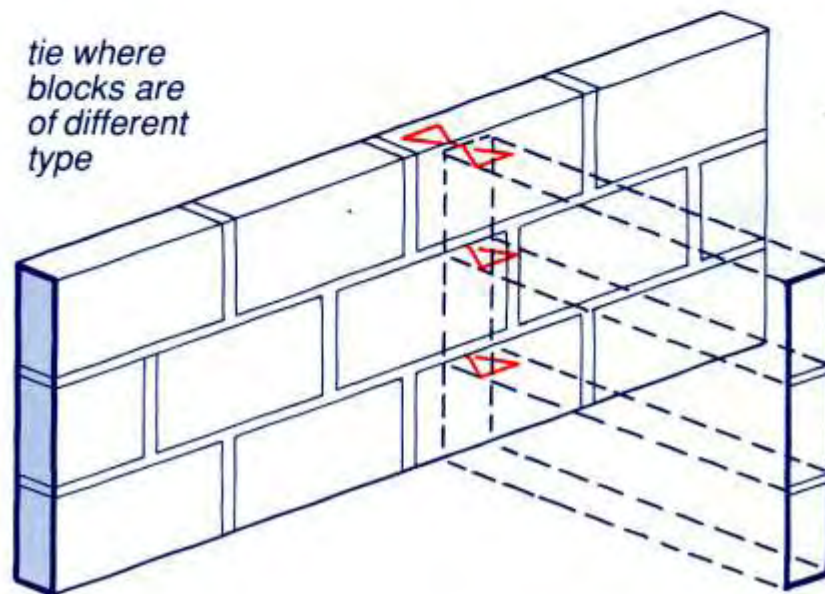
At openings and movement joints, wall ties should be spaced at maximum 300mm centres vertically even if this means cutting cavity insulation to insert the tie. Doubling the number of wall ties at 450mm or 600mm centres vertically is *not* an acceptable alternative.



bond where blocks are the same type

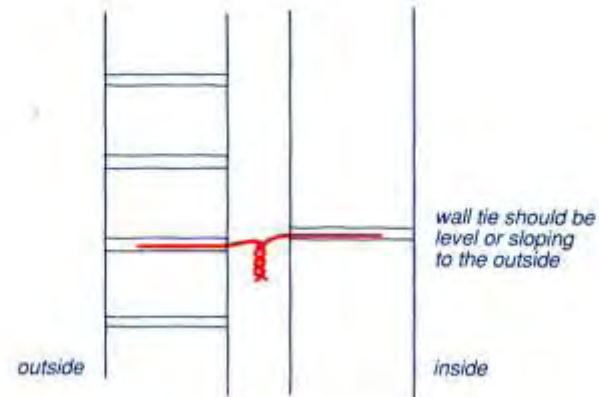


tie where blocks are of different type

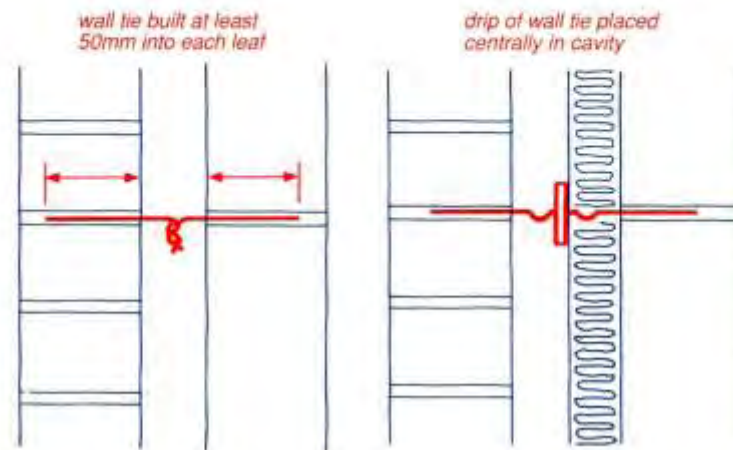


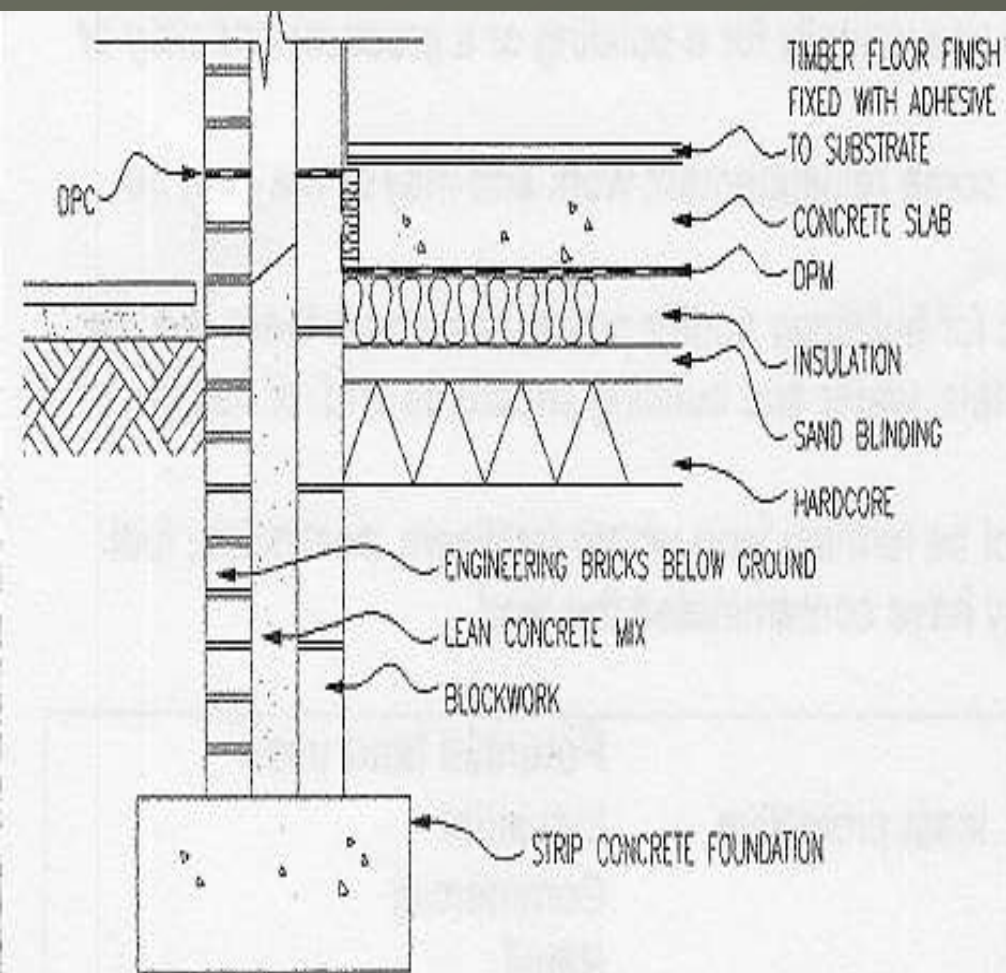
If ties slope down to the inner leaf, if drips are off-centre or if ties have mortar droppings on them, water can cross the cavity.

The two leaves should be coursed so that the wall tie is level or slopes outwards.

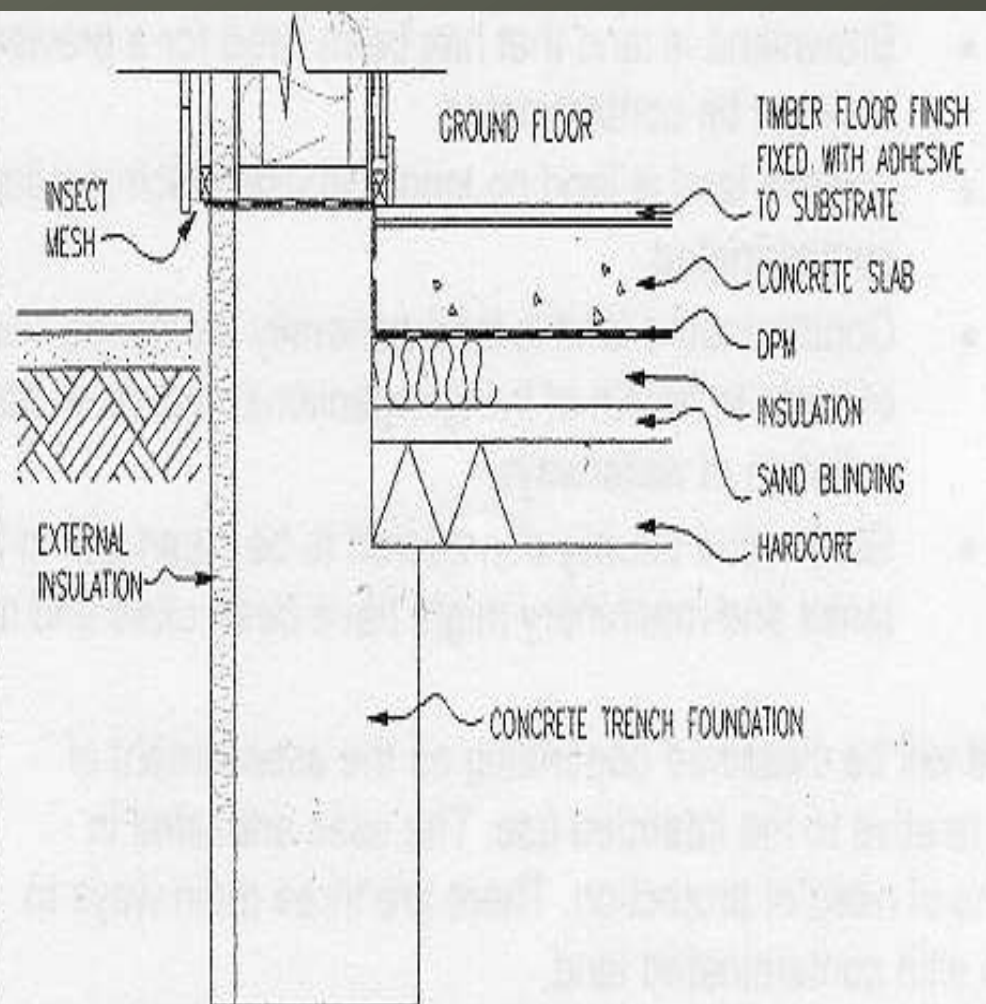


Ties should be bedded a minimum of 50mm into each leaf of the wall as work proceeds. The drip should face downwards. Ties should be built-in, not pushed into joints.

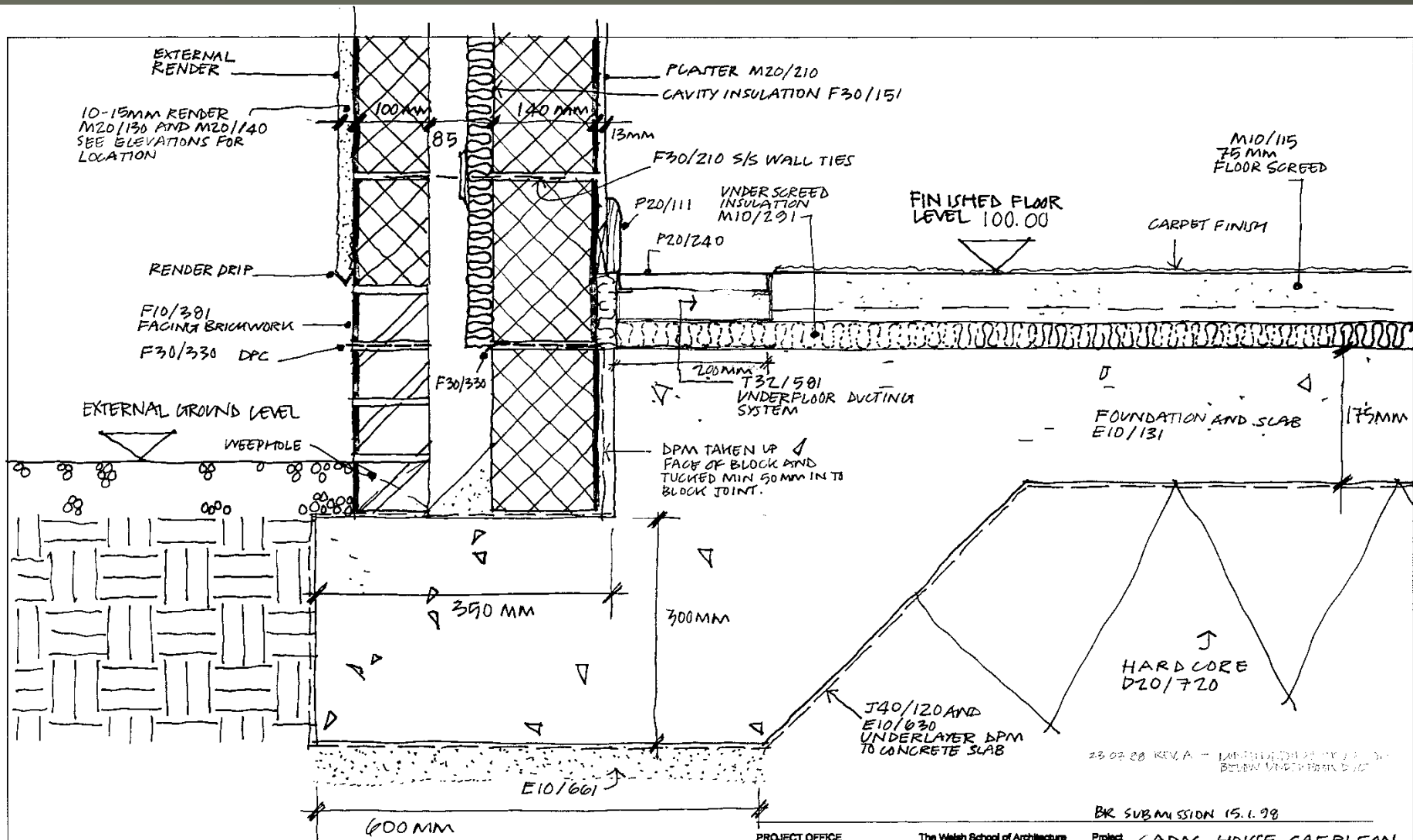




Strip foundation with cavity wall



Trench foundation with timber frame



BR SUBMISSION 15.1.98

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Drawing SECTION FOUNDATION EXT WALL
TO EXTENSION

Scale 1:5 Drawn by IS Checked

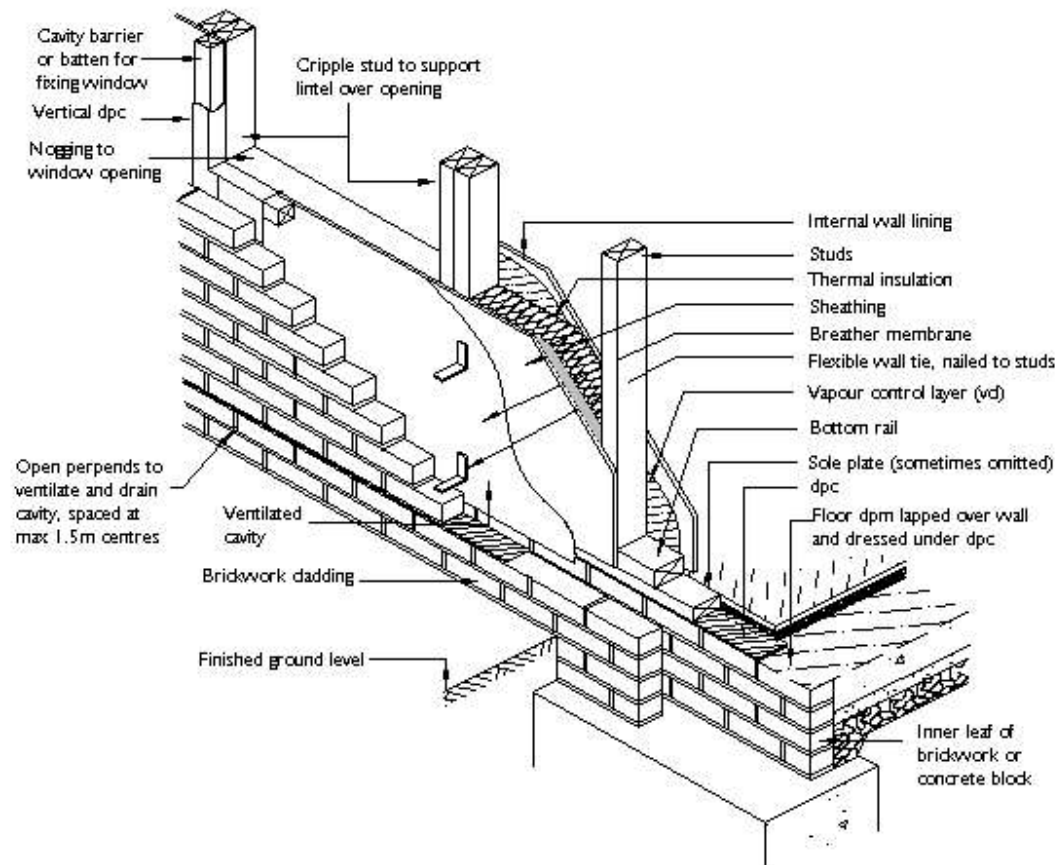
Date 30/9/97 Drawing No. 9501 A(1)01 A

Do not scale off this drawing

Dimensions for fixed-in items to be taken from site

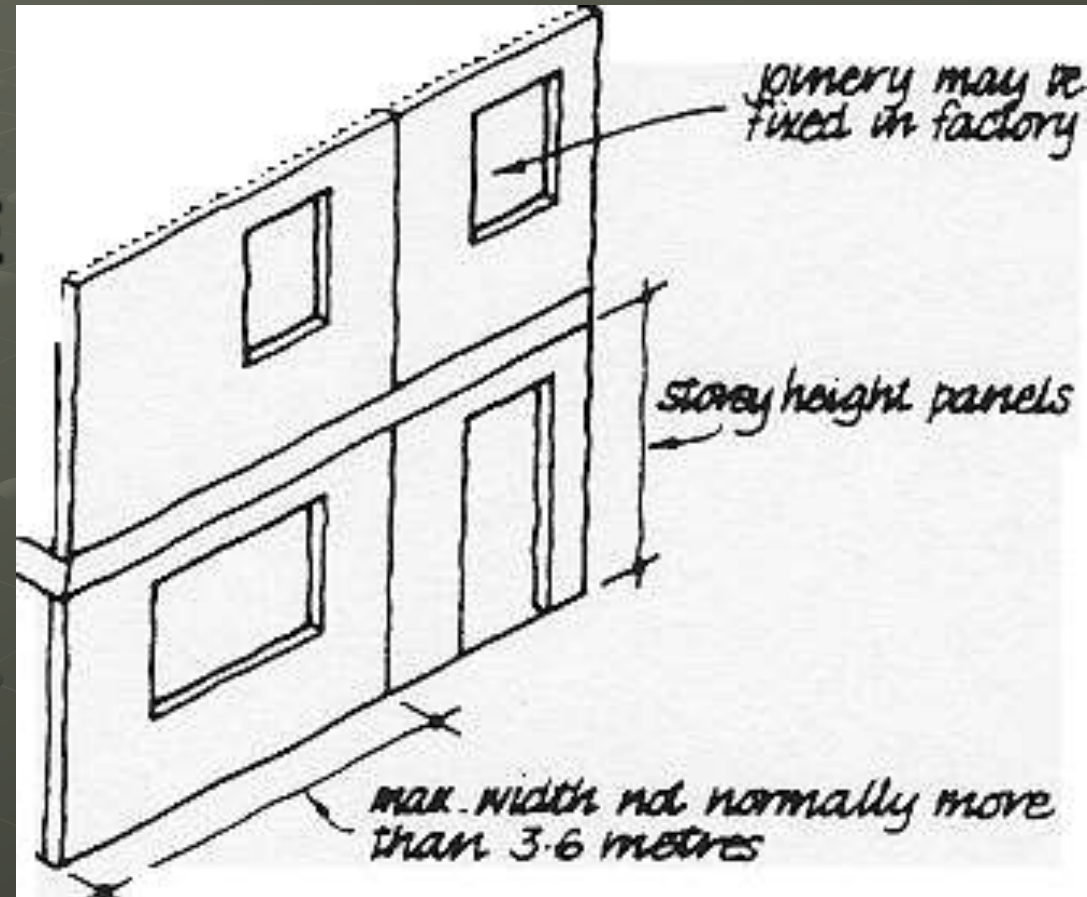
TIMBER FRAME WALLS

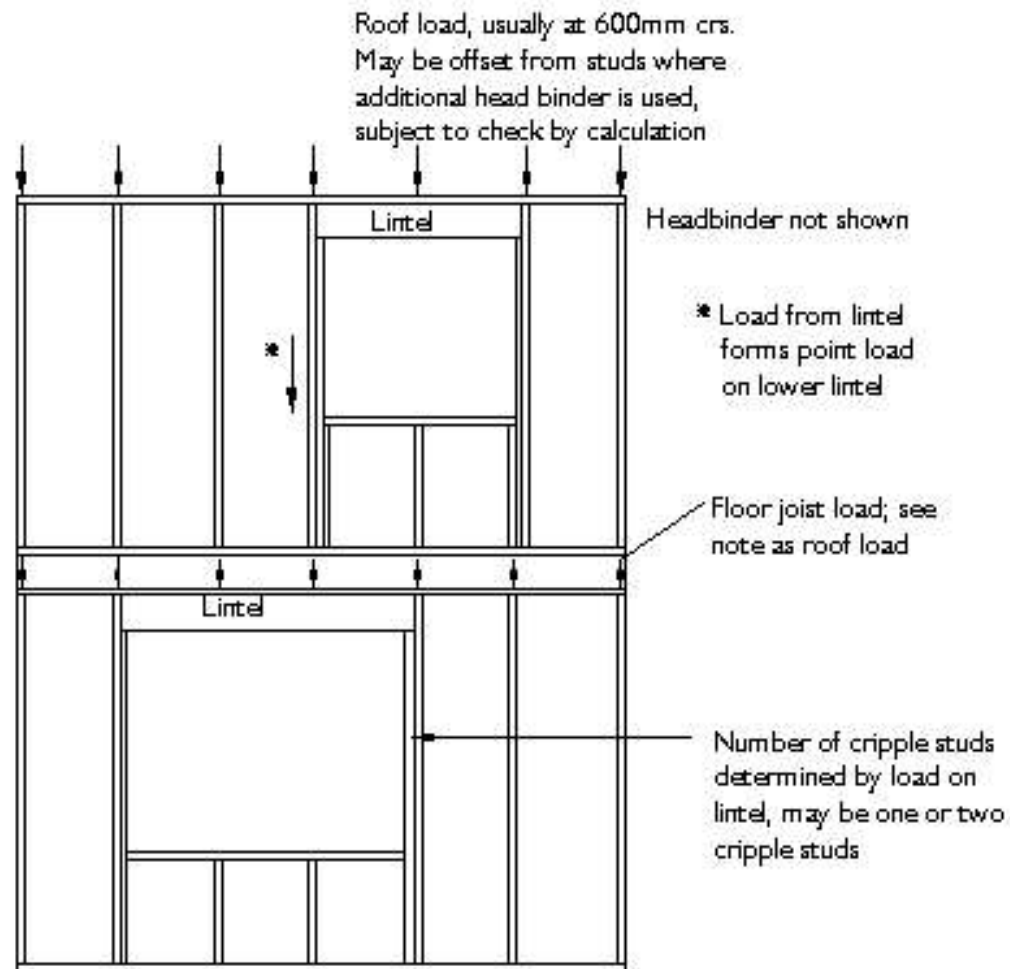
- the structural timber frame wall comprises load bearing vertical members which carry all the dead and imposed loads in the structure.

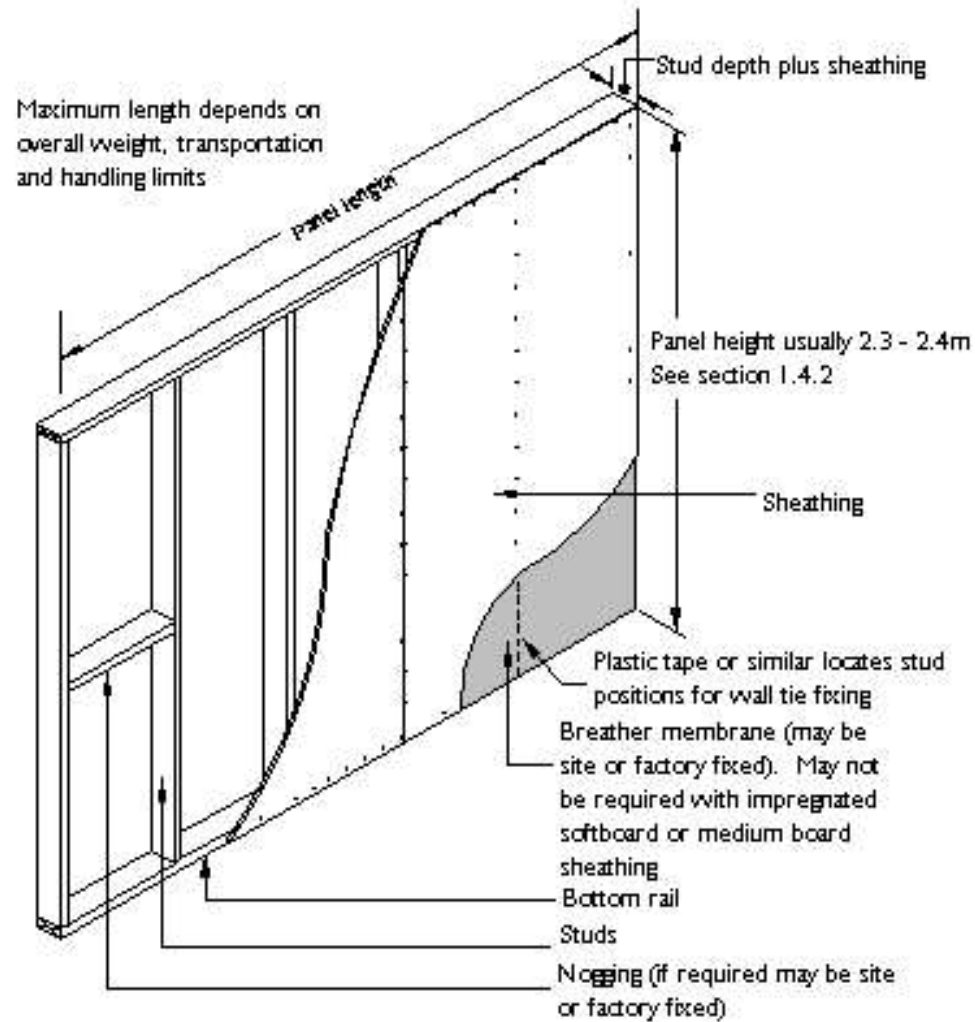


TIMBER FRAME WALLS

- Framing Methods
- PLATFORM FRAME

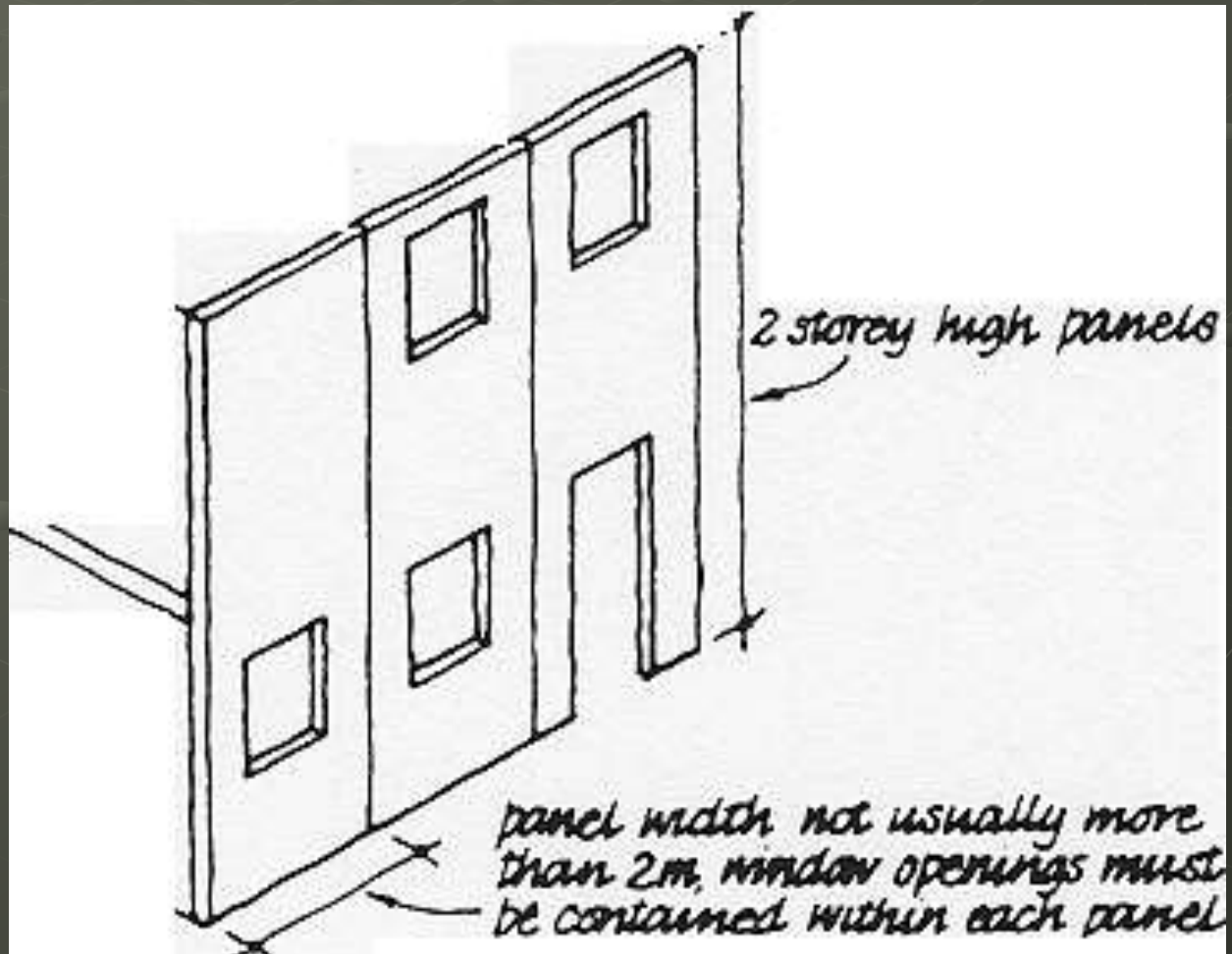






TIMBER FRAME WALLS

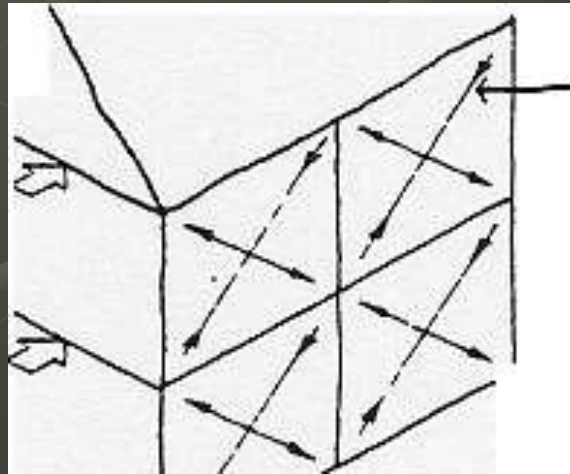
● BALLOON FRAMING



TIMBER FRAME WALLS

● Wind Loading

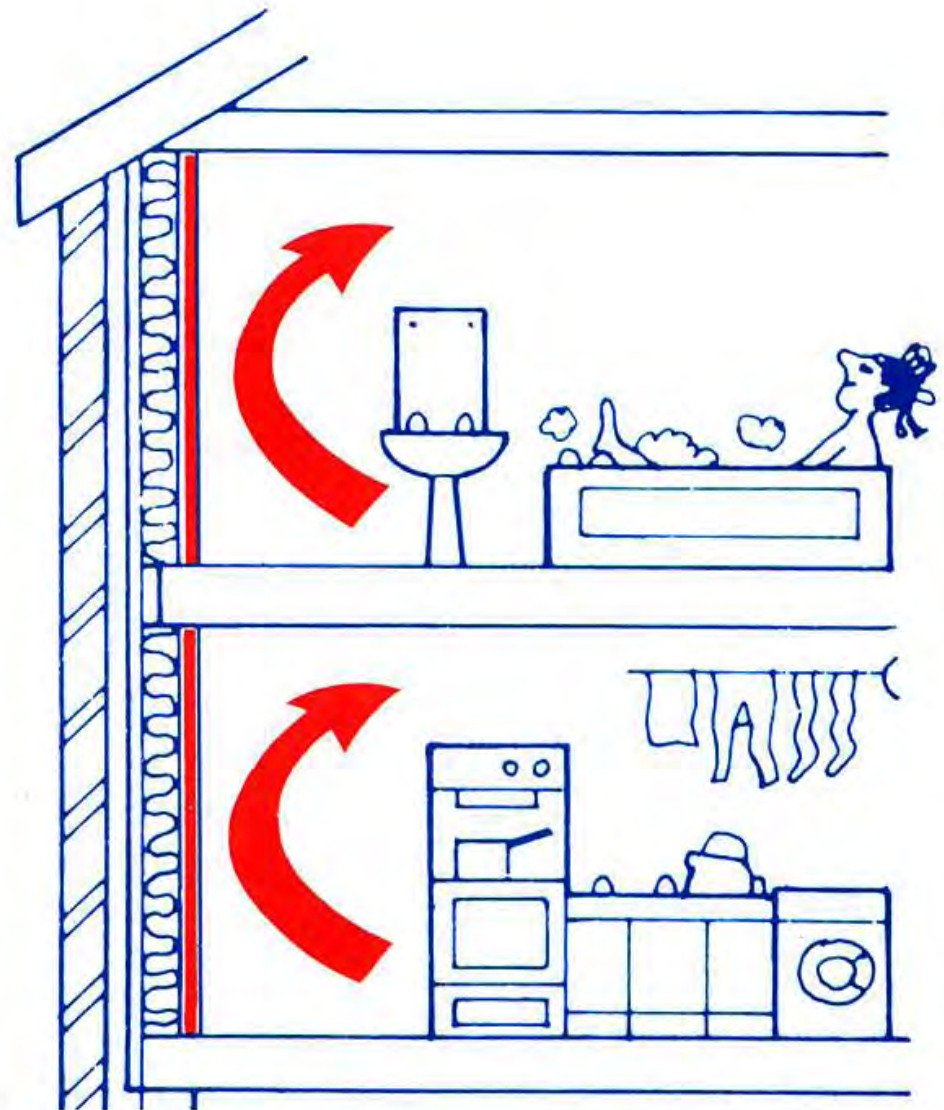
- The racking resistance of the timber panels must be sufficient to carry the wind loading on the building and this is provided by the panel sheathing.
- Plywood sheathing is presently the most popular material. Internal plasterboard linings also make some contribution to wall stiffness but this is not usually taken into account in calculations for wind resistance



TIMBER FRAME WALLS

- Advantages of timber as a building material:
- Aesthetics / various options on appearance
- renewable source/ low embodied energy
- easily worked
- buildings 3 – 5 storey high
- lightweight
- prefabricated

Vapour Control

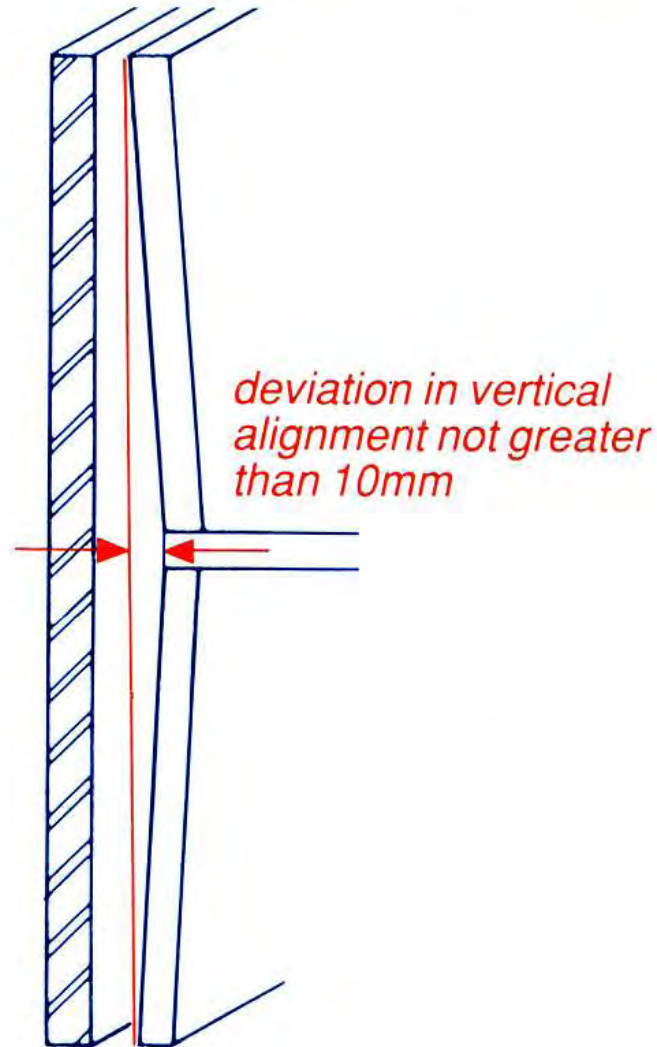


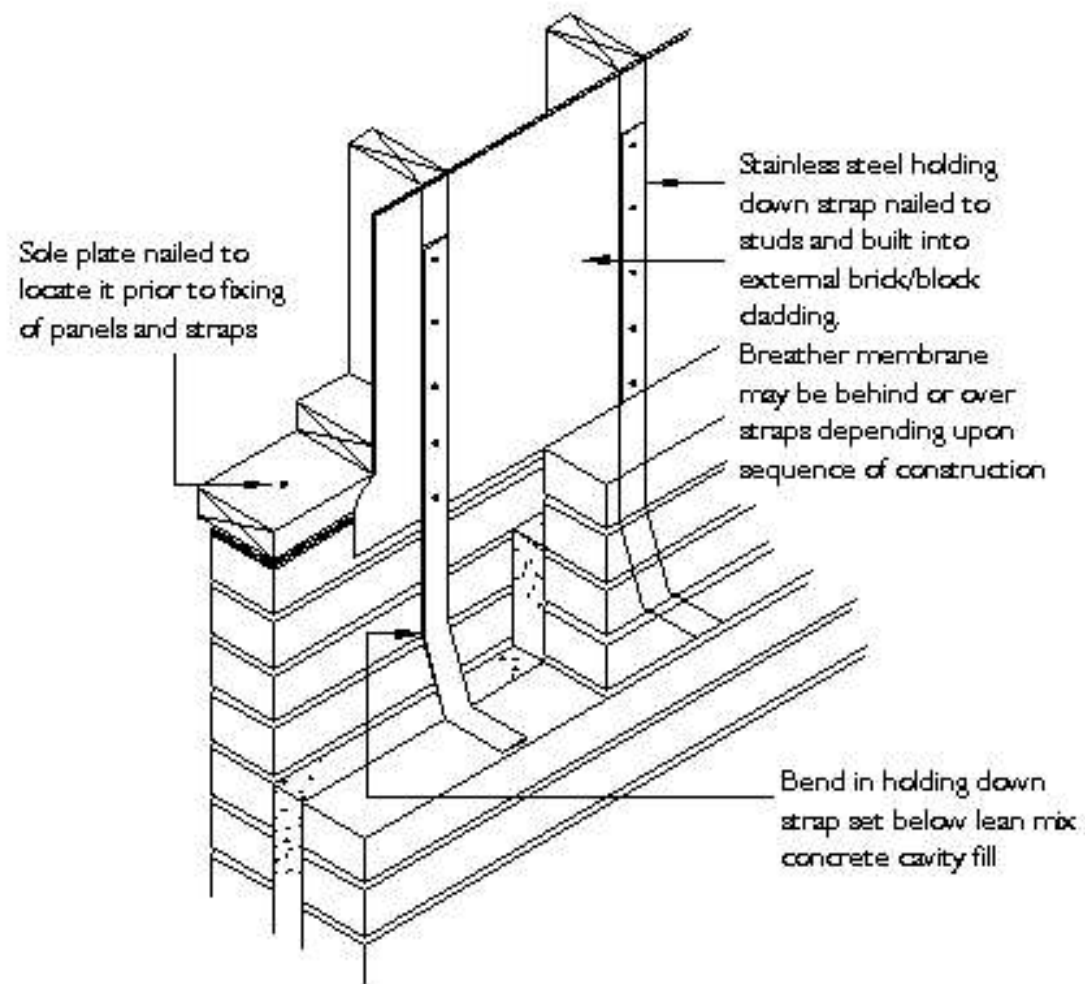
*vapour control layer
preventing moisture getting
into timber frame walls*

Structural Tolerance

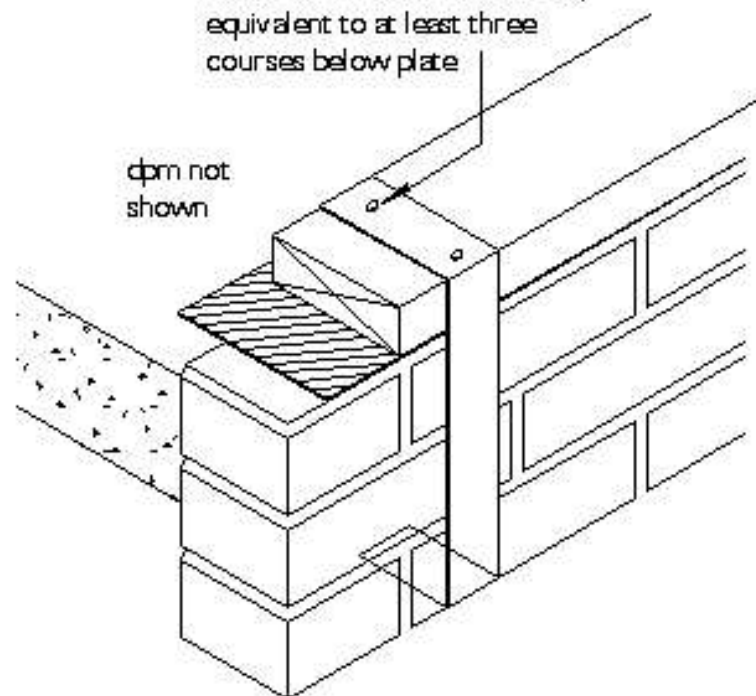
Deviations in vertical alignment should not exceed 10mm in any storey height.

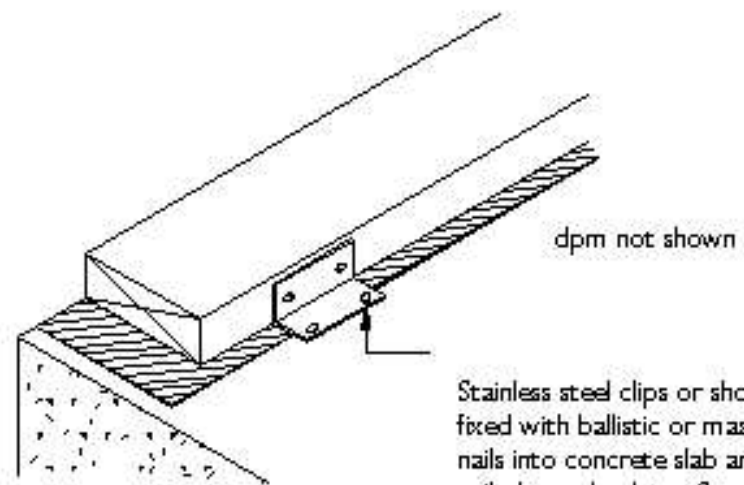
*minimum width of
cavity maintained*





Stainless steel sole plate straps
built into brickwork or blockwork,
nailed to sole plate with nails 38mm
long maximum. Straps may extend
into inner or outer leaf of wall,
equivalent to at least three
courses below plate





Stainless steel clips or shoes
fixed with ballistic or masonry
nails into concrete slab and
nailed to sole plate. Spacing
as calculated

There are a number of proprietary
stainless steel shoes available

40 mm * minimum if thickness of non-combustible material around flue liner is less than 200 mm

* Note: In Scotland, joists and timber wall framing should be at least 200 mm from the internal surface of the flue

50 mm cavity maintained around chimney with cavity wall ties as required

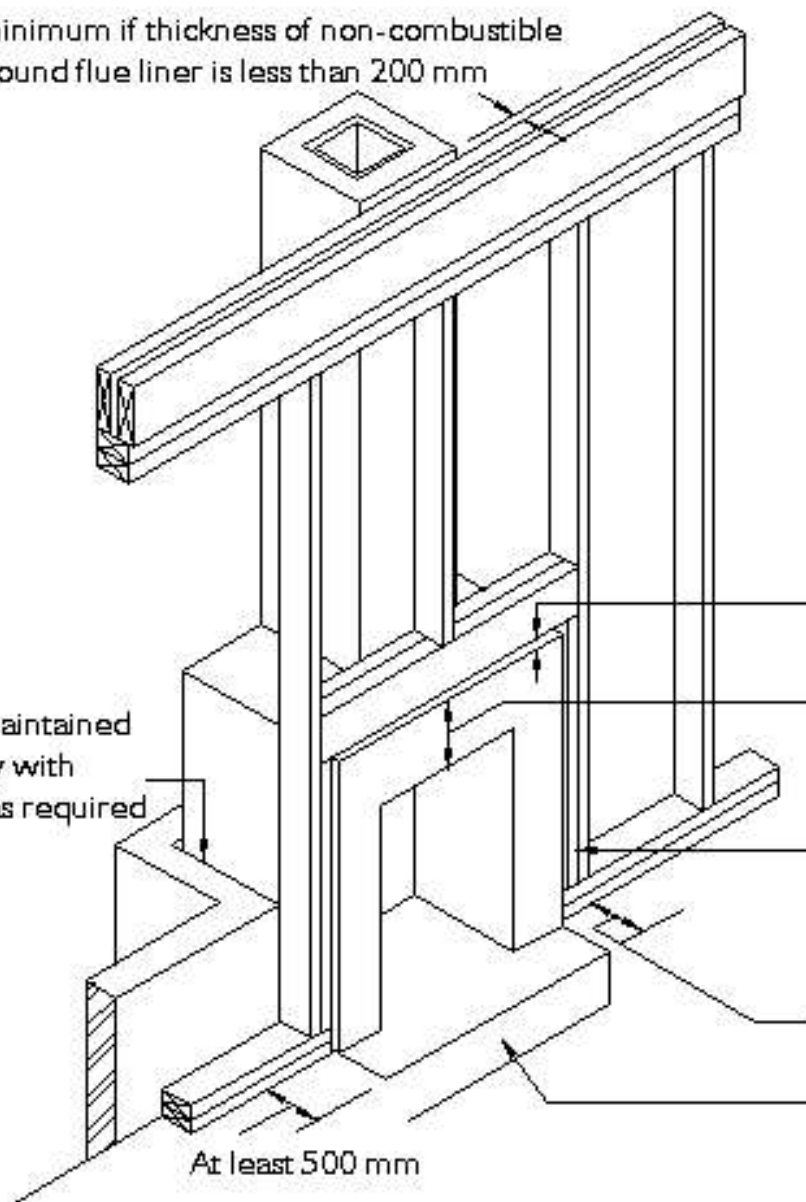
Movement gap between timber and masonry to be filled with mineral wool

Timber lintel must be at least 300 mm from inner face of flue recess
Cripple studs to lintel, gap to brickwork filled with mineral wool

At least 500 mm

At least 125 mm thick

At least 500 mm



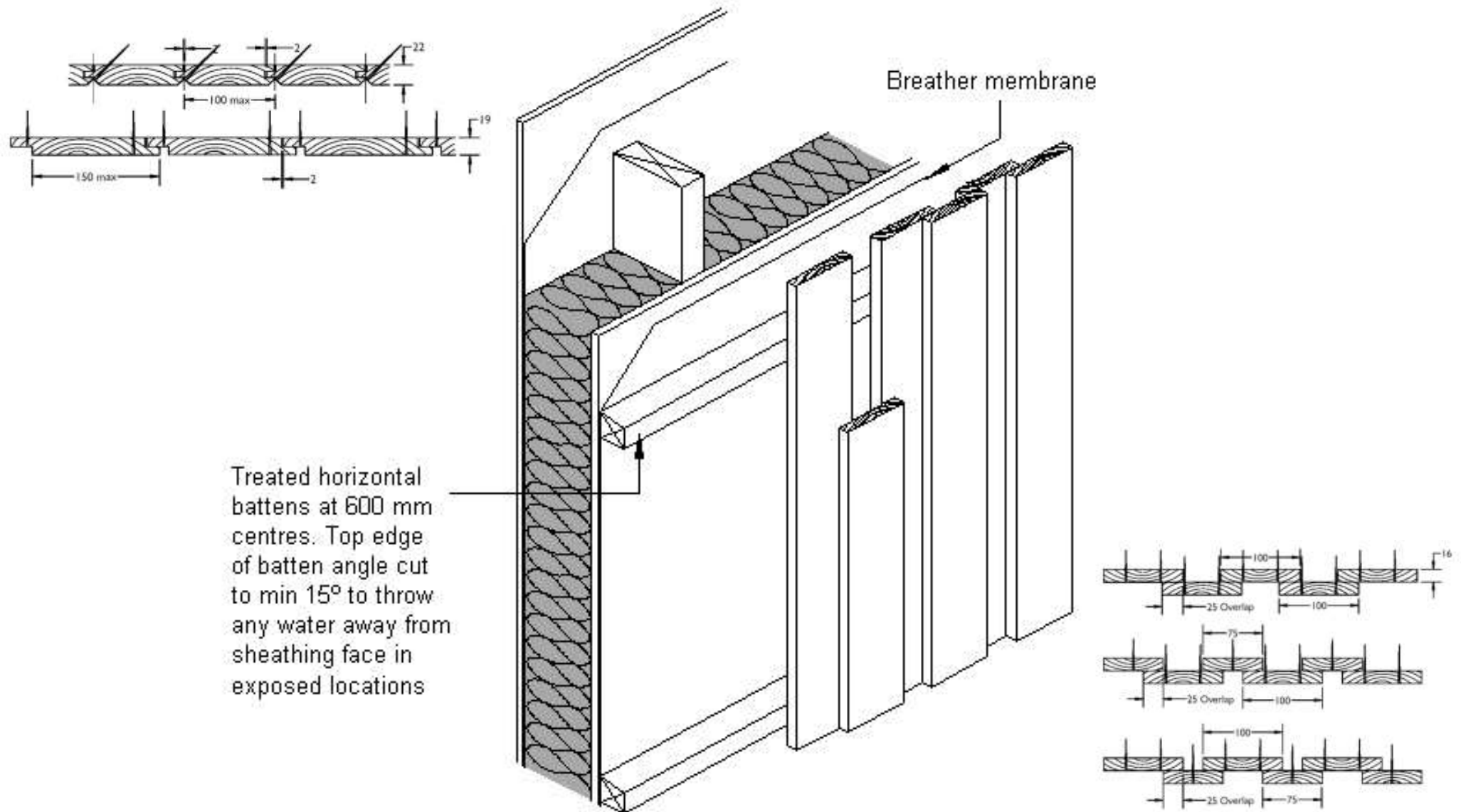
TIMBER FRAME CLADDING

- Thin/ lightweight materials such as timber boarding, tile hanging, cement render on mesh etc. which can be fixed directly back to the timber panel.
- Heavier materials such as brickwork or blockwork which are built independently off their own foundation and tied back to the timber panel for stability

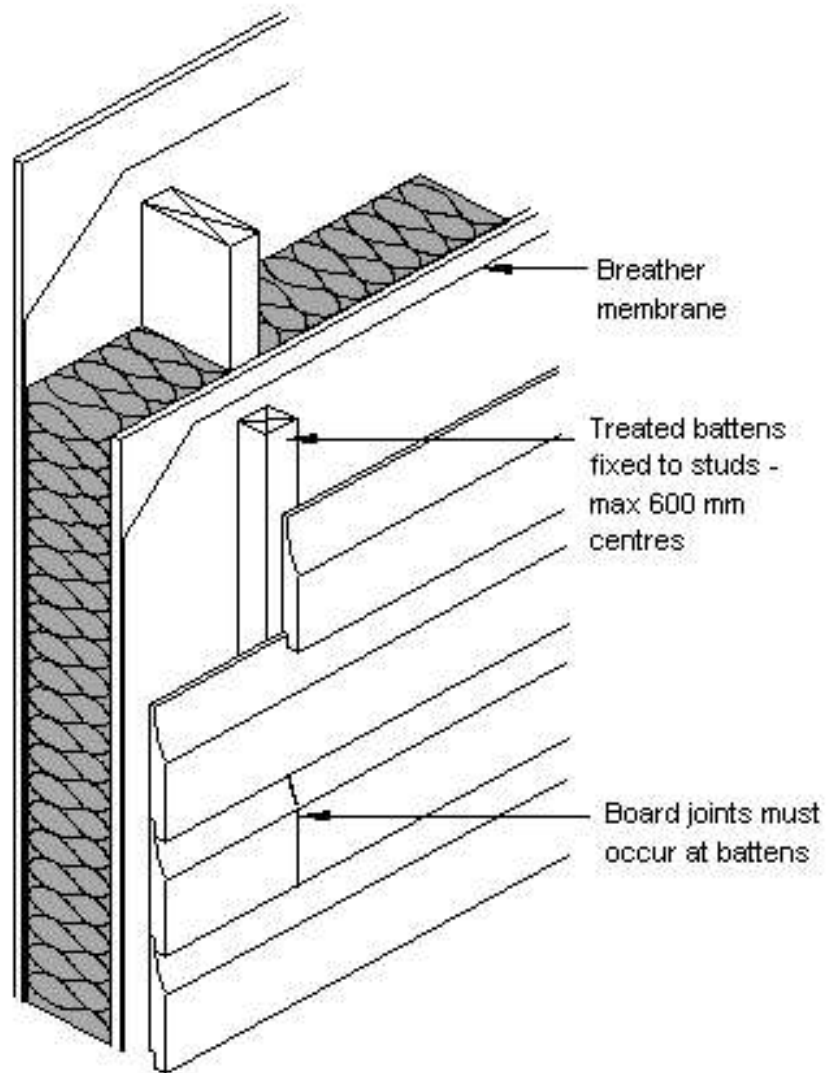
Breather Membranes

- It is common practice to fix a waterproof breather membrane over the outer face of the timber panel after completion of the shell to provide temporary weather protection during construction and a second line of defence against water penetration of the cladding. It is important that the material used should not trap moisture within the structure. They should be impervious to liquid water but permeable to water vapour.

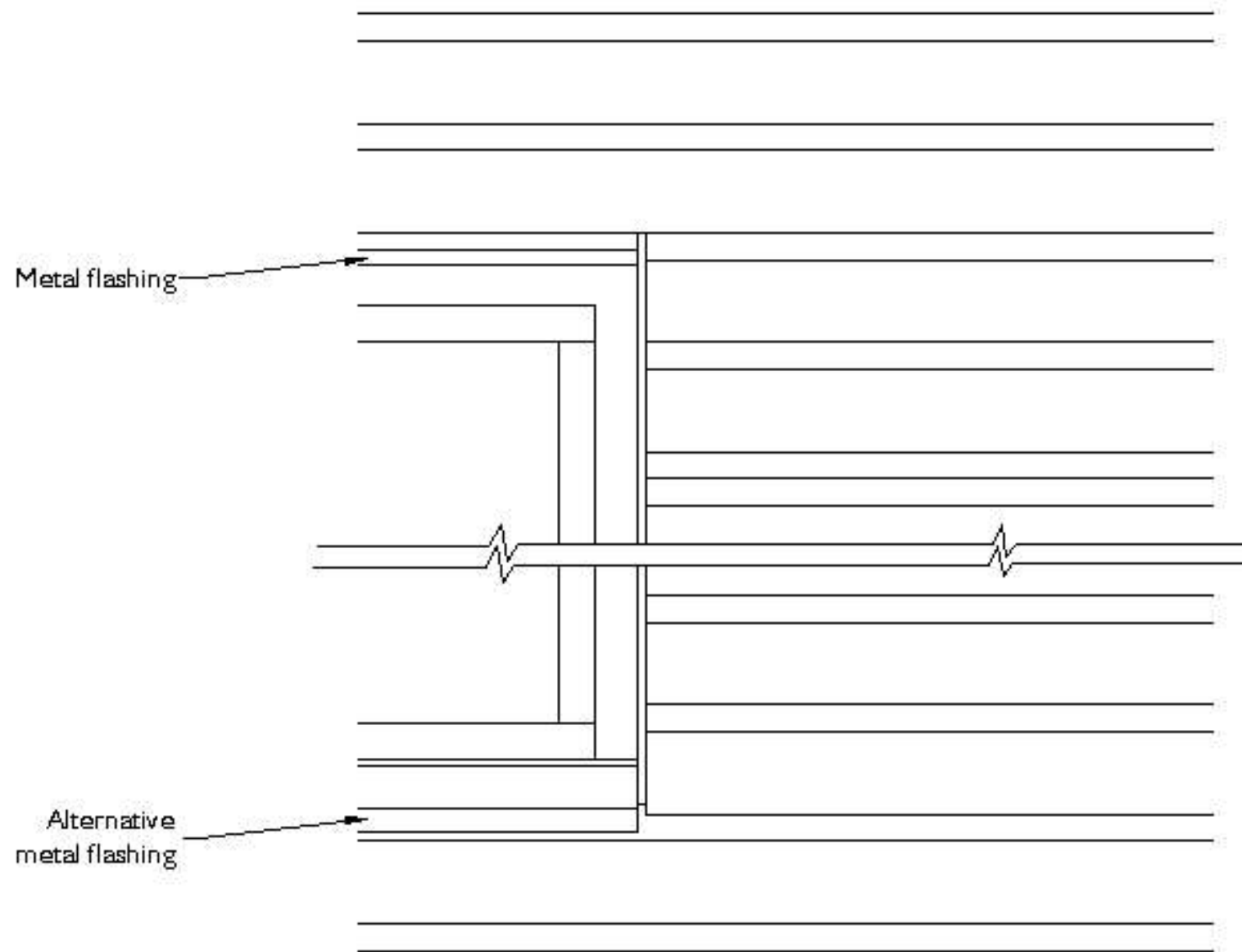
CLADDING OPTIONS



CLADDING OPTIONS



Horizontal Cladding



Conclusions

Choice of construction depends on:

- Appearance/aesthetic
- Load- vertical/lateral & shear
- Climatic factors
- U values

Further considerations:

- Cost & availability of materials
- Occupancy patterns
- Cost & availability of skills/labour
- Buildability
- Durability
- Fire resistance
- Noise reduction
- Toxic emissions
- Regional context
- Vandalism
- Maintenance
- And many more.....

Questions to think about...

- What methods of constructing an external wall would ensure that the internal surface is dry at all times?
- What are the advantages or disadvantages of completely filling the wall cavity with insulation?
- What are the advantages/disadvantages of timber frame wall construction?

Reading List & further info

- **Building Research Establishment.** *BRE thermal insulation avoiding risks.* BRE Garston, 1989.
- **D Osbourn.** *Introduction to building*, in Mitchell's Building Series. Longman, Harlow 1993.
- **Jack Stroud Foster.** *Structure & fabric Part 1*, in Mitchell's Building series, 6th edition. Longman, Harlow 2000
- **Michael McEnvoy.** *External components*, in Mitchell's Building series. Longman, Harlow 1994
- **Alan Everett.** *Materials*, in Mitchell's Building series, 5th edition. Longman, Harlow 1994
- **Bruce Martin.** *Joints in Buildings.* Godwin 1977.
- **W.B. McKay.** *Building Construction Volumes 1-4.* Longman.
- Architect Christopher Day 1971-74 self build with friends - Anti-consumer culture Christopher Day's Book - Building with Heart 1990